1 A

NUEXCO

NOVEMBER 1986 NUMBER 219

MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

Three Park Central 1515 Arapahoe Street, Suite 1045 Denver, Colorado 80202

HEADQUARTERS

Chairman of the Board of Partners
Oren L. Benton

Vice Chairman of the Board of Partners and Chief Executive Officer
Samuel R. Freeman

Directors of Operations
Business and Financial Affairs — James E. Lewis
Administration — J. Fred Lawrence
Legal and Regulatory Affairs — Frederick J. Boyne

NUEXCO FUEL BROKERAGE SERVICES

Manager of Fuel Brokerage
Earl E. Hoellen, Jr.

BROKERAGE SERVICE LOCATIONS

UNITED STATES

DENVER
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

Managing Broker
Earl E. Hoellen, Jr.

MENLO PARK
Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

Managing Broker
George White, Jr.

EUROPE

FERNEY-VOLTAIRE
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

Managing Broker
James E. Vaughan

ZURICH
135 Zurichstrasse
CH-8700 Kusnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

Managing Broker
Donald P. Ebright

REGIONAL MANAGING BROKERS

AFRICA
James E. Vaughan

AUSTRALIA
George White, Jr.

FAR EAST
Earl E. Hoellen, Jr.

NORTH AND SOUTH AMERICA
Earl E. Hoellen, Jr.

(See inside back cover for list of Representatives and Consultants.)

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

November 1986 No. 219

R. WESLEY MILLER, *EDITOR* CLARK M. BEYER, *ASSOCIATE EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Data Table 3
Prices Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 7

ANALYSIS AND COMMENTARY

Effects of the Chernobyl Accident On Worldwide Nuclear Power Programs 11

ESSAY

Chernobyl In Perspective 19

RECENT DEVELOPMENTS

South Africa 22
Switzerland 22
United States 23

FOCUS

The Price-Anderson Act 25

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 27
Historical Exchange Value, Transaction Value and Conversion Value 28

GOVERNMENT STATISTICS

Australia 29
Canada 30
South Africa 31
United States 32

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein.

© NUEXCO 1986

To Our Readers

As part of its expanding international scope of activities, Nuexco is pleased to announce its association with a group of businessmen of international stature known to many in the nuclear industry. This group, still being expanded, is the International Advisory Committee to the Chief Executive Office of Nuexco; it also counsels with Nuexco's parent, Concord-Nuexco International Corporation, and its non-nuclear affiliates. Members of the committee directly participate in the providing of various Nuexco services, including merger and acquisition arrangements, major financing arrangements, and arbitration services, while counseling on unusual technical, business and political aspects of some of the current complex brokerage transactions. This distinguished group is led by Bob Wolcott as Chairman. Its relationship with Nuexco and its affiliates is coordinated by Wayne Fowler, and, as to nuclear and non-nuclear activities in Europe, by Don Ebright. The group meets regularly every few months, having met in Geneva in June during the Palexpo meetings of the AIF, and in London in September during the Uranium Institute meetings.

J. Robert (Bob) Wolcott

Mr. Wolcott, formerly Chairman of Nuexco, is a resident of California. He now serves as a Consultant to Nuexco and as Chairman of the Concord-Nuexco International Advisory Committee. Mr. Wolcott was employed by General Electric for over 20 years prior to 1968, including being manager of design for the Dresden 1 nuclear power station, G.E.'s first commercial venture in nuclear power. He also managed manufacturing, an electronics products section, and international functions.

T. J. (Tom) Barendregt

Dr. Barendregt, formerly President of Nucon B.V. nuclear engineering contractors in Amsterdam, is a resident of Blaricum, the Netherlands. Dr. Barendregt has, during the last 25 years, served as Director for the construction and operation of a reprocessing plant for irradiated fuels, EUROCHEMIC, in Mol, Belgium; Senior Manager of Comprmo B.V., petroleum and nuclear engineering contractors in Amsterdam; and President of, and subsequently a Consultant to, Nucon B.V. Dr. Barendregt has also served as Assessor Special de Presidente, Empresas Nucleares Brasileiras S.A. (NUCLEBRAS) in Rio de Janeiro, Brazil.

Leland O. Erdahl

Mr. Erdahl, formerly President and Chief Executive Officer of Ranchers Exploration and Development Corporation, is a resident of New Mexico. Mr. Erdahl was employed from 1957 to 1967 by the U.S. Atomic Energy Commission at Grand Junction, Colorado and Washington, D.C. in various capacities, including Director of the Finance and Budget Division and Chief of the Audit Planning and Program Branch. He subsequently was employed by United Nuclear Corporation in Santa Fe, New Mexico, and from 1970 to 1984 by Ranchers Exploration and Development Corporation.

Lars Halle

Mr. Halle, formerly President of ASEA-ATOM, is a resident of Stockholm, Sweden. He is a graduate of the Swedish Royal Institute of Technology in Stockholm. Mr. Halle served from 1948 to 1957 as Production Manager at the AD Ifoverken, from 1957 to 1963 in ASEA's Nuclear Power Department, and from 1964 to 1968 as President of ASEA's South Africa Pty in South Africa. Mr. Halle returned to Sweden in 1968 as Vice President of Cementa and from 1968 to 1984 served as President of ASEA-ATOM.

© NUEXCO 1986

O. J. C. (John) Runnalls

Dr. Runnalls, a resident of Toronto, Canada, worked for 20 years for Atomic Energy of Canada Ltd. until 1971, when he was appointed Senior Advisor, Uranium and Nuclear Energy in the Department of Energy, Mines and Resources in Ottawa. He also served for 5 years as Executive Vice President of Uranium Canada Ltd. Since 1979, he has been associated with his alma mater, the University of Toronto, and is presently Chairman of the Centre for Nuclear Engineering.

George J. Stathakis

Mr. Stathakis, formerly President and Chief Executive Officer of General Electric Trading Company, is a resident of New York. Mr. Stathakis has affiliated with Nuexco as a Consultant on international investment banking and will assist in several of Nuexco's service capabilities. He spent approximately 20 years in the nuclear power business with General Electric, where he became General Manager of the Atomic Power Equipment Project in 1967, and Vice President and General Manager of the Nuclear Energy Division from 1971 to 1977.

James C. C. Stewart

Mr. Stewart, formerly Managing Director, Production Group, for the United Kingdom Atomic Energy Authority (predecessor of British Nuclear Fuels plc), is a resident of London, England. Mr. Stewart, a physicist, has been involved in radar, nuclear weapons, nuclear power and various other businesses. He has also served on the Board of the United Kingdom Atomic Energy Authority and Central Electricity Generating Board. He was Chairman of the Radio-Chemical Centre, Emersham International (involved with radio isotopes), Deputy Chairman of Nuclear Power Company Ltd. (reactor design and construction), and Director of National Nuclear Corporation Ltd. (reactor design and construction). Mr. Stewart has served as a Consultant to Nuexco for several years.

W. Bryan Webster

Mr. Webster, after an early career from 1943 to 1947 in the Manhattan Project in Oak Ridge, Tennessee, was employed by General Electric for 35 years. Mr. Webster worked for 15 years in various positions of Project Management and for 12 years as General Manager of the Power Plants Projects Department, managing procurement, construction and startup of 30 domestic and international plants. Mr. Webster has been a consultant to General Electric and Nuexco and is a resident of California.

* * *

Nuexco will host a hospitality suite during the Atomic Industrial Forum's Annual Conference at the Washington Hilton in Washington, D.C., November 16-19. We look forward to seeing you there.

* * *

Our US offices will be closed for the Thanksgiving holiday on Thursday, November 27 and Friday, November 28. Our European offices will be open for business on those days.

© NUEXCO 1986

NUEXCO

PRICING

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of October 31, 1986)

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,740,000** pounds U_3O_8 equivalent, down 310 thousand pounds since last month. The corresponding figure for **active demand** is **950,000** pounds, down 465 thousand pounds. The spot and near-term **supply-demand ratio** rose to **3.9:1.**

The *Current Market Data* section of this Report lists six natural uranium sales involving approximately 1.0 million pounds equivalent U_3O_8. All of the transactions involved spot or near-term delivery, and all met the criteria for inclusion in the current Transaction Value calculation. Four of the transactions involved natural UF_6.

The **Transaction Value** is **$17.25** per pound U_3O_8, down $0.10 since last month. The calculation extends over a 3-month period and includes 13 transactions involving 2.4 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$48.00** per kilogram U in UF_6, unchanged since last month.

The **Conversion Value** is **$1.90** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 2.0 million pounds U as UF_6. Active demand totals 650 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

The **Loan Rate** is **4 percent** per annum, unchanged. One loan transaction, involving 100 to 300 thousand pounds U_3O_8 equivalent, is reported.

* * *

The Exchange Value and UF_6 Value were unchanged this month, as the market for natural uranium continues to exhibit the same fundamental characteristics that have prevailed since June, when US District Court Judge Carrigan handed down his decision in the lawsuit involving three US producers and DOE. Since the Tenth Circuit Court of Appeals granted DOE's request for a stay of judgment pending appeal, and absent any decision on that appeal, most market participants have remained cautious. Discretionary buyers have been waiting for the emergence of a clearer picture of price trends, and sellers have been hoping to see a significant upward price movement.

In recent weeks, industry attention has shifted away from developments in Senator Domenici's draft legislation and DOE's proposed enrichment criteria (see Reports 215, 216 and 217, July-September 1986). The Domenici bill was not passed during the recently adjourned session of Congress, but parts of it may be reintroduced in 1987. By withholding funding for the implementation of five key sections, Congress effectively nullified the most controversial provisions of DOE's proposed enrichment criteria. (See page 23 of this Report). Therefore, market participants have refocussed their attention on the US producers' lawsuit against DOE. It has once again become the primary hope for a resolution of the uncertainty that pervades the market. Until the Appeals Court renders its judgment, that uncertainty probably will continue.

It is important to recognize that a decision, when rendered by the Tenth Circuit Court of Appeals, will *not necessarily* dispose of all the issues in the case. For example, the case could be remanded to Judge Carrigan for further findings or it could be appealed to the US Supreme Court (but only if the Supreme Court agreed to hear the appeal). It is still possible that the Appeals Court could issue a strong, definitive opinion, such that the Department of Justice would decide to pursue the issue no further. Despite that possibility, market participants should be prepared for any of several alternatives.

The current trends in the uranium market have created a number of conflicting pressures for buyers and sellers. Unlike coal or oil, uranium concentrates have the same energy content regardless of their origin, yet origin has become one of the most important considerations in uranium pricing. Not only does each country participating in the nuclear industry have its own political position with regard to uranium production, sales, purchases, or reprocessing, but some countries even have conflicting standards among different regions or companies. In the FRG, for example, the utility in Hamburg is prohibited by local government policy from buying Southern African uranium, while a utility in the more conservative southern part of the nation may prefer uranium of that origin because of its lack of end-use restrictions. Similarly, from the view of some utilities in the USA that have overseas enrichment contracts, US uranium will carry no premium value even if the Circuit Court rules in favor of the US producers.

US-origin uranium continues to command a premium relative to the current Exchange Value, despite the fact that no legal requirements are in effect that would force US utilities to buy or enrich only US material. A considerable amount of US-origin uranium has been sold to US utilities in the last five months through origin-swap mechanisms. The continuing availability of US-origin uranium through swaps has enabled buyers to remain firm in their unwillingness to pay US producers' substantially higher asking prices. Nevertheless, some US producers have made sales at or slightly above the $17.00 level. When the

© NUEXCO 1986

Appeals Court granted DOE's request for a stay, demand for US-origin material subsided. Several utilities had completed all their desired purchases of US-origin material; others stayed out of the market, awaiting a judicial resolution of the market uncertainity.

Canadian-origin concentrates and UF_6 continue to sell for prices near the Exchange Value and the UF_6 Value, respectively. However, prices often vary substantially, depending on the timing and location of deliveries. The Canadian government's upgrading policy still stands in the way of concentrate sales to many utilities, both in Europe and in the USA. When exceptions to that policy are granted, the cost of transporting concentrates to Europe may offset the discounts available for material delivered in North America.

South African and Namibian uranium have become politically unacceptable in the USA and several European countries. Thus, its value in the spot market is limited. However, some buyers in Europe and the Far East still accept Southern African uranium; in fact, some prefer it to Canadian, Australian, or US-origin material because of the lack of prior approval required for reprocessing or retransfer of that material.

* * *

The Conversion Value was unchanged this month, as the secondary market remained largely inactive. No transactions are reported this month, but as of the end of the month, one potential buyer of a large quantity of secondary market conversion services was evaluating offers from several sellers.

In mid-October, the Nuclear Regulatory Commission voted unanimously to authorize the restart of Sequoyah Fuels Corporation's UF_6 conversion plant in Gore, Oklahoma. The authorization is contingent upon certain conditions specified in an NRC order modifying the license for the plant. Among other conditions, an independent consultant must monitor operations at the plant and report to the NRC. The facility was shut down in January 1986 following an accident that killed one worker and injured several others. Several months ago, Sequoyah was given permission to resume deliveries of UF_6 from its stockpile and receive U_3O_8 shipments. Because of conversion overcapacity worldwide, the interruption at Sequoyah seemed to have little impact in the overall demand for UF_6, and any uncertainties regarding the future of Sequoyah's operation apparently had no effect on either the demand or price of secondary market conversion services. Nevertheless, the NRC action should relieve any pressure on utilities concerned about security of UF_6 supply.

* * *

ENRICHED URANIUM AND SWUS

The **SWU Value** as of October 31, 1986, is $78 per SWU, unchanged since last month. This refers to SWU at a tails assay of 0.30 weight-percent U_{235} and for delivery within one year. Three secondary market SWU transactions are reported this month, involving approximately 100 thousand SWU.

The three transactions reported this month generally cover the range of SWU opportunities available in today's secondary market. Decreasing quantities of DOE-origin virgin SWUs are still available in the range of $85 to $100 per SWU, and can be used to upgrade the enrichment assay of larger amounts of enriched product. SWUs contained in enriched product (usually at any of several common enrichment assay levels) are typically available in much larger quantities, and command prices between $72 and $80 per SWU.

© NUEXCO 1986

CURRENT MARKET DATA

October 31, 1986	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**\$17.00**/lb. U_3O_8	3,740	950
UF₆ VALUE	**\$48.00**/kgU		
CONVERSION VALUE	**\$1.90**/lb. U as UF_6	1,965	650
SWU VALUE 0.3 tails assay: delivery within one year	**\$78**/SWU		
LOAN RATE	**4%**/annum	0	0

	\$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.25**	2.4	13	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1986

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Oct 31, 1986)**	**Last Month (Sep 30, 1986)**	**12 Months Ago (Oct 31, 1985)**	**This Month (Oct 31, 1986)**	**Last Month (Sep 30, 1986)**	**12 Months Ago (Oct 31, 1985)**
Australia (dollar)	26.46	27.06	23.51	68.79	70.34	61.13
Belgium (comm. franc)	724.95	714.29	873.94	1,885	1,857	2,272
Canada (dollar)	23.61	23.58	22.55	61.38	61.32	58.63
Finland (markka)	84.75	83.37	92.54	220.32	216.75	240.59
France (franc)	113.86	112.29	132.32	296.02	291.92	344.00
FRG (mark)	34.85	34.32	43.43	90.60	89.21	112.91
Italy (lira)	24,107	23,800	29,188	62,672	61,873	75,882
Japan (yen)	2,742	2,608	3,507	7,128	6,780	9,119
Netherlands (guilder)	39.43	38.90	48.79	102.52	101.14	126.84
South Africa (rand)	38.64	37.53	42.04	100.45	97.56	109.29
Spain (peseta)	2,334	2,269	2,647	6,068	5,900	6,883
Sweden (krona)	119.13	117.48	129.62	309.71	305.43	336.97
Switzerland (franc)	28.90	27.81	35.56	75.14	72.31	92.45
UK (pound)	12.12	11.85	11.51	31.51	30.80	29.91
US (dollar)	17.00	17.00	16.50	44.20	44.20	42.90

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Oct 31, 1986)**	**Last Month (Sep 30, 1986)**	**12 Months Ago (Oct 31, 1985)**	**This Month (Oct 31, 1986)**	**Last Month (Sep 30, 1986)**	**12 Months Ago (Oct 31, 1985)**
Australia (dollar)	26.85	27.61	22.45	69.80	71.79	58.35
Belgium (comm. franc)	735.61	728.99	834.22	1,912	1,895	2,168
Canada (dollar)	23.96	24.07	21.53	62.28	62.58	55.97
Finland (markka)	85.99	85.09	88.33	223.56	221.22	229.65
France (franc)	115.54	114.60	126.30	300.38	297.93	328.36
FRG (mark)	35.36	35.02	41.46	91.94	91.05	107.78
Italy (lira)	24,461	24,290	27,861	63,594	63,147	72,433
Japan (yen)	2,782	2,661	3,348	7,233	6,919	8,704
Netherlands (guilder)	40.01	39.70	46.57	104.03	103.22	121.07
South Africa (rand)	39.20	38.30	40.13	101.92	99.57	104.32
Spain (peseta)	2,369	2,316	2,527	6,158	6,021	6,570
Sweden (krona)	120.88	119.90	123.72	314.27	311.72	321.65
Switzerland (franc)	29.33	28.39	33.94	76.24	73.80	88.25
UK (pound)	12.30	12.09	10.98	31.97	31.43	28.55
US (dollar)	17.25	17.35	15.75	44.85	45.11	40.95

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Oct. 31, 1986.

© NUEXCO 1986

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6 This Month (Oct 31, 1986)	per lb. U as UF_6 Last Month (Sep 30, 1986)	per lb. U as UF_6 12 Months Ago (Oct 31, 1985)	per kg. U as UF_6 This Month (Oct 31, 1986)	per kg. U as UF_6 Last Month (Sep 30, 1986)	per kg. U as UF_6 12 Months Ago (Oct 31, 1985)
Australia (dollar)	2.96	3.02	2.28	6.52	6.67	5.03
Belgium (comm. franc)	81.02	79.83	84.75	178.63	176.00	186.83
Canada (dollar)	2.64	2.64	2.19	5.82	5.81	4.82
Finland (markka)	9.47	9.32	8.97	20.88	20.54	19.78
France (franc)	12.73	12.55	12.83	28.06	27.67	28.29
FRG (mark)	3.90	3.84	4.21	8.59	8.46	9.29
Italy (lira)	2,694	2,660	2,830	5,940	5,864	6,239
Japan (yen)	306.45	291.46	340.14	675.61	642.55	749.87
Netherlands (guilder)	4.41	4.35	4.73	9.72	9.59	10.43
South Africa (rand)	4.32	4.19	4.08	9.52	9.25	8.99
Spain (peseta)	260.88	253.64	256.74	575.14	559.17	566.01
Sweden (krona)	13.31	13.13	12.57	29.35	28.95	27.71
Switzerland (franc)	3.23	3.11	3.45	7.12	6.85	7.60
UK (pound)	1.35	1.32	1.12	2.99	2.92	2.46
US (dollar)	1.90	1.90	1.60	4.19	4.19	3.53

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU Value delivery within one year (Oct 31, 1986)	UF_6 Value per kg.U in UF_6 This Month (Oct 31, 1986)	UF_6 Value per kg.U in UF_6 Last Month (Sep 30, 1986)
Australia (dollar)	121.40	74.71	76.40
Belgium (comm. franc)	3,326	2,047	2,017
Canada (dollar)	108.32	66.66	66.59
Finland (markka)	388.83	239.28	235.41
France (franc)	522.44	321.50	317.04
FRG (mark)	159.90	98.40	96.89
Italy (lira)	110,607	68,066	67,199
Japan (yen)	12,581	7,742	7,363
Netherlands (guilder)	180.93	111.34	109.84
South Africa (rand)	177.27	109.09	105.96
Spain (peseta)	10,710	6,591	6,408
Sweden (krona)	546.60	336.37	331.72
Switzerland (franc)	132.61	81.60	78.53
UK (pound)	55.60	34.22	33.45
US (dollar)	78.00	48.00	48.00

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Oct. 31, 1986.

© NUEXCO 1986

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3848	1987	301-600	104	Producer	Utility	UF_6.
3847	1986	50-100	102	Producer	Utility	US origin.
3835	1987	50-100	108	R[5]	Utility	UF_6. US origin.
3834	1987	101-300	108	Trader	Utility	UF_6. US origin.
3825	1986	less than 50	100	Producer	Utility	
3822	1987	101-300	102	Trader	Utility	UF_6.

Loan Transactions

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Borrower	Remarks
3811	1986	101-300	R[5]	Utility	Producer	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
3846	1987	less than 50	less than 92	R[5]	Utility	R[5]	
3843	1987	less than 50	105-106	Trader	Utility	DOE	
3842	1987	50-100	101	Trader	R[5]	DOE	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.

[3] Price is not normalized to 0.20% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., the X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1986

CURRENT MARKET DATA

URANIUM SUPPLY
(October 31, 1986)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or long term**	**Remarks**
Available for Sale:			
ACTIVE			
2335	400	—	
2740	100	—	
2764	260	—	UF_6
2777	500	—	
2880*	100	—	
2885B	325	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121*	500	—	
3129*	500	500	
2263	—	400 per year	1988 on
2625	—	500 per year	1988 on
2781	—	250 per year	1988-95
2927	—	220 per year	1988-90
2981	—	600 per year	1988-91
TOTAL:	3,740		
INACTIVE			
2297	200	200 per year	1988-89
2336	250	250 per year	1988-94
2389	75	75 per year	1988-90
TOTAL:	525		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2889, 3127.

© NUEXCO 1986

URANIUM DEMAND
(October 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2893*	200	—	UF_6
2948	100	—	UF_6
2954*	50		
2956*	350	350	U_3O_8 or UF_6
2962*	250		
2738	—	1,000	1989 on
2739	—	1,000 per year	1987-90
2962*	—	500	1989 on
3019*	—	200 per year	1988-91
TOTAL:	950		
INACTIVE			
2760	750	750 per year	1988-90
2798	70	—	
2681	—	500	UF_6 or U_3O_8; 1988
2936	—	400 per year	1988-95
TOTAL:	820		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2782, 2784, 2877, 2955.

CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(October 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2667	800	—	
2920	2,000	—	
TOTAL:	5,300		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

No inquiries to borrow are reported this month.

CONVERSION SUPPLY AND DEMAND
(October 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
ACTIVE			
2849	550	500	1987-90
2859	750	750	
2935	500	—	
2988	165	—	
TOTAL:	1,965		
Inquiries to Purchase:			
ACTIVE			
2833	400	—	
2949	250	—	
TOTAL:	650		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

© NUEXCO 1986

SWU SUPPLY AND DEMAND
(October 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571	—	55	1987
2855	250	—	
2957*	10	—	
TOTAL:	260		
Inquiries to Purchase:			
INACTIVE			
2854*	130	—	
2878	60	—	
2879	250	—	
2999	—	300	
2968*	10	—	
3015	85	—	
TOTAL:	535		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2410, 2873, 2923, 2953.

© NUEXCO 1986

NUEXCO

ANALYSIS & COMMENTARY

EFFECTS OF THE CHERNOBYL ACCIDENT ON WORLDWIDE NUCLEAR POWER PROGRAMS

Introduction

The April 1986 accident at Chernobyl in the USSR has already had a considerable effect on some nuclear power programs throughout the world. During the six months since the accident occurred, many countries have been reexamining their plans for nuclear power development. In several countries there have been postponements of decisions to order new nuclear plants, and early decommissioning of reactors has become a topic of discussion. The strongest reactions to the Soviet accident took place in Western Europe. Considering that region's proximity to the radioactive release from the Soviet plant, and the influence of historically anti-nuclear environmental movements in several countries, such reactions were predictable.

The political positions taken against further nuclear expansion have generally reflected the negative shift in public attitudes toward nuclear power in Western Europe. Because of the highly negative publicity, also, most pro-nuclear politicians have remained quiet, waiting until a more reasoned discussion of nuclear issues can take place. Much of the public and media alarm over nuclear power following the Chernobyl accident has diminished with the passage of time, and earlier emotional reactions have slowly changed into a more rational outlook. Most of the projects or facilities that have been targets of protest or political activity since the Soviet disaster had been controversial prior to that event.

The following examples briefly summarize the varying reactions to Chernobyl.

1. The Federal Republic of Germany (FRG), Sweden, Finland, the Netherlands, Italy, and Austria have all experienced strong negative public reactions to the Chernobyl accident. The FRG and Sweden now appear to have suffered little damage to their nuclear programs despite intense political activity. Nuclear programs in Finland, the Netherlands, Italy, and Austria face the possibility of: (1) cancellations of planned nuclear plants; (2) shutdowns of units under construction; or (3) closures of completed facilities.

2. Spain, Yugoslavia, and Taiwan have postponed decisions on plans for future reactors.

3. The United Kingdom and Brazil have engaged in heated debates over their nuclear plans, but no firm decisions have been made.

4. France, Belgium, Japan, South Korea, and India all stress that their commitments to nuclear power remain firm.

5. The countries of Eastern Europe, along with the Soviet Union, continue to plan for rapid expansion of nuclear power.

Outside Europe, few changes in either nuclear planning or nuclear plant operations have resulted directly from the accident at Chernobyl, although some actions that might have taken place anyway have been attributed to it. However, virtually all countries with nuclear industries have initiated safety studies of various kinds, examining technical aspects of plant design and public disaster planning. But in sum, the negative consequences of the Chernobyl accident appear to affect the worldwide nuclear industry primarily in the areas of actual or potential deferrals of orders for new plants.

In general, repercussions from the accident at Chernobyl can be divided into the technical and the social-political areas. Nuclear physicists, engineers and other technical experts are examining the reports issued by the Soviet Union, as they analyze the causes of the accident. Since that event, reactor manufacturers and utilities in the West have spent much time and energy to reassure the public that safety standards in force outside of the Soviet Union are much more strict, emphasizing essential differences in Western reactor designs and safety systems.

In countries where opponents of nuclear energy have enough power to influence policy, the reaction to Chernobyl may affect operating nuclear plants, units still under construction, or those in the planning stage. Whether any currently operating power plants will be closed because of the political response will probably depend on the results of upcoming elections, as well as on serious studies of the alternatives to nuclear power generation.

Although political reactions to the Chernobyl accident have been dramatic, in most cases they have been less negative than they appeared at first, considering the scope of the damage and the effect of radioactive fallout on nearby countries. In many cases, decisions about orders for future plants have been postponed until after the completion of studies aimed at reexamining reactor designs and safety systems, as well as the sizes of evacuation zones and other disaster planning measures.

The following sections discuss in more detail some of the effects of the accident at Chernobyl on the international nuclear industry.

Western Europe

Since the late 1970s, the **Federal Republic of Germany** (FRG) has experienced a great deal of political controversy over nuclear power. Activists opposed to nuclear power are well organized in the FRG, and virtually all the nuclear installations that have been the targets of political pressure or public demonstrations after Chernobyl had also experienced active opposition before the Soviet accident. The Brokdorf nuclear power station, for example, was the site of violent demonstrations during the 1970s. This facility, on the River Elbe, is the first new unit in the FRG to come into operation since the accident at Chernobyl.

The two main opposition parties in West German politics, the Social Democratic Party (SPD) and the Green Party, have strengthened their stands against nuclear power since the Chernobyl accident. The Greens now call for an immediate, permanent, nationwide shutdown of all nuclear power plants. The SPD, a party that in some states depends on the Greens for a coalition majority, advocates withdrawing from nuclear power generation over a ten-year period. The SPD has traditionally opposed technologies that produce or process plutonium to a much greater extent than they have opposed basic nuclear power. Their opposition to any nuclear power generation has emerged only since the Chernobyl accident, and could be a short-term political response to the public's concern over the safety of nuclear plants.

The ruling national coalition of the Christian Democratic Union (CDU) and the Christian Socialist Union (CSU) reacted to the Soviet disaster by creating a new Cabinet post, Minister for the Environment and Nuclear Safety. The Minister, Walter Wallmann, is thought to have been chosen by conservative interests to placate the opposition. One of the Minister's first official actions was to initiate a study of reactor safety. Political analysts in the FRG closely watched the parliamentary elections held in June in Lower Saxony, traditionally considered a conservative state. Coming so soon after the Chernobyl accident, the election showed some erosion in the majority held by the Christian Democratic Union party, but the SPD and the Green Party alliance failed to gain enough seats to take power.

In the state of Hesse, the Green Party has been applying pressure on the state government to phase out all nuclear power in that state. The Green Party has a minority political presence with the SPD in that state's coalition government, but the Green's cooperation is needed by the SPD to maintain their coalition majority. Two 1300-MWe PWRs at Biblis, and a fuel fabrication plant in Hanau, are located in Hesse. Controversy over the Biblis-A unit, a 1200-MWe PWR in operation since 1974, has intensified since the federal government's Environment and Nuclear Safety Minister announced that he has asked the International Atomic Energy Agency (IAEA) for an Operational Safety Review Team (OSART) to visit the Biblis plant and others. The coalition of the SPD and the Green Party maintains that an inspection by the IAEA would not be strict enough, as inspection teams do not make thorough evaluations of reactor design. The Green Party has said that it will withdraw from the coalition with the SPD if the SPD does not, by the end of this year, support the Green's intent to shut down the Biblis Unit-A plant.

In North-Rhine Westphalia, Economics Minister Reimut Jochimsen has pointed to studies made for his ministry that he says indicate serious and possibly unresolvable technical problems in the Kalkar fast breeder reactor. He has denied the necessary license for fuel loading and start-up operation. Jochimsen has long been highly critical of the Kalkar project, and as North-Rhine Westphalia's top licensing authority, his opinion and influence are significant. Political opponents, however, have accused Jochimsen of using his position to advance his Social Democratic Party's anti-nuclear posture. The extent to which the SPD can claim public support for its platform should become more evident after several state elections are held, and after the federal elections scheduled for January 1987.

In late June, West German border police in the state of Bavaria turned back Austrian anti-nuclear demonstrators heading for the site of the Wackersdorf reprocessing plant in Bavaria, which is in the preliminary stage of construction. This incident prompted a diplomatic exchange between the two countries that focused international attention on the facility. In July, the demonstrators were allowed to cross the border to participate in protests against the plant. In late 1985 Wackersdorf was the target of violent protests at the plant site. Elections held in Bavaria in early October returned the conservative Christian Social Union to power by a safe margin. Party leader Franz Josef Strauss continues to support construction of the Wackersdorf reprocessing plant. Critics want the Wackersdorf facility indefinitely postponed or canceled, even though earthmoving and heavy construction are underway at the site.

Austria's government recently announced its intention to sell off the assets of Gemeinschaft Kernkraftwerk Tullnerfeld's (GKT) Zwentendorf unit, a 742-MWe BWR that was completed in 1978 but never commissioned. In June 1986, a study by Bechtel Power Corporation examined the options for selling the plant, either in part or as a whole unit. The study concluded that financial losses would be so great, and the possibilities of a sale so slight, that the Austrian government would be better off simply closing the plant in the hope that a future shift in the political climate might allow the plant to begin operation. Since then, public opinion in Austria has swung firmly against nuclear power. While the Chernobyl accident had a strong impact on public opinion in Austria, any decision to abandon the Zwentendorf project can be blamed only partially on the disaster in the Soviet Union. In fact, until the mothballed plant is actually dismantled, a reversal of the decision is still possible, though unlikely.

In **Switzerland,** the Chernobyl accident has provoked an active debate in the news media and in Parliament. The end result, however, is little change in Switzerland's program. The debate in Parliament this October focused on the questions of a nuclear phase-out, and a moratorium on construction of the Kaiseraugst plant. Parliament rejected outright any proposal of a nuclear phase-out for Switzerland, but reached no decision on the ground-breaking for Kaiseraugst. The consensus in Parliament was a strong desire to continue with nuclear power.

It has been nearly 20 years since the first siting permit request for Kaiseraugst, and several local communities have asked the government for new assurances of the plant's safety, including evacuation planning and protective measures against radioactive emissions. The evaluation of bids for Kaiseraugst continues although the date for selection of a supplier has been postponed until mid-1987 to allow for a more thorough analysis of bids. Both the Goesgen and Kaiseraugst sites have been controversial since long before the accident at Chernobyl occurred. That event has, however, provided the catalyst for renewed protests against those projects.

Wanting to capitalize on the public reaction to the Chernobyl disaster, Swiss anti-nuclear activists are trying to gather the necessary signatures to call a national referendum that would place a moratorium on all nuclear planning and construction for ten years. This signature gathering, however, has been in progress ever since a similar referendum was defeated several years ago. Even if enough signatures are obtained, the government can take up to five years before putting the referendum to a vote. Past anti-nuclear referenda have been defeated, the last time by a vote of about 55 percent to 45 percent in September 1985. Even though news coverage of the Chernobyl accident was extensive, and anti-nuclear feeling among the Swiss public increased, it is possible that such proposals will again be defeated.

In **France,** the government's commitment to nuclear energy appears to be unshaken following the Chernobyl accident. However, public sensitivity to the nuclear issue has risen following the accident at the Soviet facility, and also after several recently announced incidents at French facilities. A poll conducted in October by the Gallup organization showed a significant decline in public confidence in nuclear power, with a majority of people expressing the opinion that France should not continue to build more reactors.

In late August, cooling water flooded lower levels of the Cattenom plant during fuel loading, delaying unit startup operation for an unknown period of time. Cattenom is located only about 15 kilometers from the borders of both Luxembourg and the German state of Saar, a region with a population of over one million within a 50 kilometer radius of the plant. While no radioactive emissions were involved, the news media certainly gave the incident extra attention because of the Chernobyl accident. Protestors demonstrated against the plant in June, and the German and Luxembourg governments took legal actions to block operation of Cattenom until detailed safety reviews could be completed. Protests against Cattenom may have intensified since the event at Chernobyl, but they began well before that. Despite the protests, Cattenom achieved criticality in late October 1985, and is expected to reach full power and be connected to the French electricity grid by the end of this year.

There has also been concern among the French public and media over the disclosure of an accident in 1984 at the Bugey Unit 5 PWR, following several equipment failures. Although the incident was not actually concealed, the handling of news about it gave the impression of having been deliberately suppressed, especially after the Chernobyl accident had sensitized the media to all nuclear-related matters. Also of concern to the public were an incident at the La Hague reprocessing plant, and the apparent reluctance of the French government to release data on atmospheric radiation levels in France immediately following the Chernobyl accident. Thus, while the overall public reaction in France has become more critical, the French commitment to nuclear energy is unchanged.

Belgium's nuclear program also appears relatively unaffected by the Chernobyl accident. Partly because Belgium shares France's confidence in nuclear energy, but also because Belgium has no new nuclear plants under construction, the Soviet disaster has had little real impact there. However, the possible ordering of an eighth unit tentatively planned for the Doel complex may be postponed for an indefinite time.

In the **Netherlands,** the government has taken a cautious approach to the nuclear question following the accident at Chernobyl. In January 1986, the government had decided to order two new nuclear plants. This decision was questioned, however, after the accident at Chernobyl. In May voters returned the Netherland's moderate-conservative coalition government to power, but the government's present attitude is to study the Soviet disaster, and to reevaluate the Netherland's nuclear future. Plans for the two new plants are now indefinitely deferred.

In **Italy,** the public reaction to Chernobyl has caused a probable withdrawal from the prospect of nuclear expansion in the future, both by Ente Nazionale per l'Energia Elettrica (ENEL), the Italian state-run utility, and by the voting public. It now appears that any expansion of nuclear power in Italy is unlikely for the near future. Parliament has scheduled a National Conference on Energy for late 1986 to reevaluate Italy's energy strategy after the Chernobyl mishap. Completion of the unit under construction at Montalto di Castro and the second unit at Trino Vercellese are now uncertain and future construction of planned PWRs in Lombardy and Puglia appears unlikely. ENEL has been actively exploring ways in which coal and natural gas can be used to meet Italy's future energy requirements.

The nuclear issue in Italy has become a sensitive part of political platforms. Italy's Radical and Green Parties have collected more than one million signatures, enough to call for a national referendum on Italy's nuclear future. It appears that this referendum will not be blocked by legal maneuvering in the court system, or by changes in the requirements for referenda. The proposed referendum lists the following three points that would be voted on.

1. Special financial incentives that make acceptance of nuclear plants more attractive to local authorities would be eliminated.

2. The power to choose nuclear sites would be placed in the hands of Parliament, rather than the present appointed committee.

3. The involvement of ENEL in international nuclear projects, such as fast breeder research and development, would be prohibited.

Although these issues themselves may not seem to provide clear choices for or against nuclear power, the proposed referendum is regarded as a politically realistic and accurate indicator of current public and political feeling.

Since the Chernobyl accident, Italy's Socialist and Communist parties have greatly increased the pressure to completely phase out nuclear power. (One of the protestors at a recent demonstration at Caorso, Italy's largest commercial nuclear facility, was Claudio Martelli, deputy to Socialist Party Prime Minister Craxi.) These parties propose decommissioning the Latina and Trino Vercellese nuclear plants, both 21 years old, and possibly also the newer BWR unit at Caorso. In general, there is now little political support in Italy for nuclear-generated electricity.

In the **United Kingdom,** the fate of the Central Electric Generating Board's (CEGB) Sizewell PWR is still very much undecided, awaiting the public inquiry report on the Sizewell application. Preliminary work on the project has been slowed to the absolute minimum while CEGB evaluates the possibility of building coal-fired power plants to replace the potentially lost capacity from Sizewell and other planned reactors. Critics have also focused attention on England's Magnox reactors. Approximately three-fourths of the UK's nuclear power generation comes from this group of reactors, which have an average age of approximately 20 years.

The age of the Magnox reactors and the uncertain outcome of a long-term safety review, initiated in 1979 following the discovery of material defects in some reactors, have made long-term planning for the future electricity production from these reactors difficult. The Chernobyl accident made it unlikely that the UK will be able to institute any program to extend the operating lifetimes of this group of reactors. In addition, the lack of secondary containment vessels over two of the early Magnox units, Berkeley and Bradwell, both placed in service in 1962, has made the public especially sensitive to design features that bear a similarity to the Chernobyl plant. Even before the accident in the Soviet Union, most of the government's political opposition was directed against additional nuclear construction. The Labour Party clearly opposes a nuclear future in Great Britain, calling for a phased withdrawal from all nuclear power within ten years.

The position of **Spain's** socialist government in opposing nuclear energy had been gradually shifting in favor of a renewed program before the Chernobyl accident. Spain's eight operating nuclear plants generated 30 percent of the country's electricity during the first half of 1986. Now, however, public sensitivity to nuclear power appears to have shifted against further reactor construction. Pending the results of a review of the national energy plan, the Spanish government has continued its suspension of construction of several nuclear plants being built. The most likely candidates for reconsideration are the Valdecaballeros units, in the province of Estremadura. Of these two 975 MWe BWRs, Unit 1 is approximately 70 percent complete, and Unit 2 is 60 percent complete.

The government of **Yugoslavia** responded to the Chernobyl accident by postponing, at least for the near term, decisions on the future construction of several nuclear plants long under consideration. The Republic of Croatia responded by removing plans for the Prevlaka 1000 MWe unit from its five-year economic development plan. Evidently, this removal does not actually take the power plant out of consideration, but allows the Croatian government to defer approval until after the tendering process has been completed and contractors chosen. Tenders from foreign and Yugoslav suppliers were submitted in June, and decisions are expected by mid-1987.

Government plans for the Prevlaka site ultimately include four reactors, that would be scheduled to begin commercial operations at the rate of one reactor per year between 2000 and 2003. Although such a schedule appears to be overly optimistic, Yugoslav engineering and fabrication companies hope to be providing nearly 100 percent of the expertise and material for the nation's nuclear power construction program by the time the third unit is complete. Yugoslavia now operates a single 664-MWe Westinghouse PWR at Krsko, near Zagreb.

Following the Chernobyl accident, public opposition to nuclear power increased a great deal in Yugoslavia, as the ban on Yugoslav food imports by EEC countries focused public awareness on nuclear issues. Immediately after the Soviet accident, polls showed three-fourths of the Yugoslav people against the construction of any new nuclear power stations, but the country's difficult energy choices and ambitious hopes for strong industrial development by the year 2000 may cause the current anti-nuclear sentiment to be short-lived.

© NUEXCO 1986

Scandinavia

In **Sweden,** the government has acknowledged the strong position of the nuclear opposition in that country, but has also tried to establish a rational economic framework for the withdrawal from nuclear power by the year 2010, presently mandated by law as a result of a referendum passed in 1980 and a subsequent vote in Parliament. A study ordered by Prime Minister Ingvar Carlsson will examine the various aspects of a possible closure of the Barsebaeck station, where two 600-MWe Asea-Atom BWRs were completed in 1975 and 1979. The study will be made by the Swedish Energy Council, which is made up of representatives from political parties, environmental groups, business, the utilities, and trade unions. Denmark has actively sought a shutdown of this reactor site since long before the Chernobyl accident. Barsebaeck is located only about 20 kilometers from Copenhagen. Even though the Swedish attitude against nuclear power has hardened, it appears unlikely that any operating plants will be shut down for decommissioning as a result of reaction to the Chernobyl disaster.

A proposal recently has been presented to Parliament that prohibits any preparation for building additional nuclear reactors in Sweden. Critics call this bill unnecessary, but it is likely to gain approval in Parliament, where several parties are competing to be considered the most anti-nuclear party. This bill, however, apparently has its roots from before the Chernobyl accident, coming from reports of reactor planning by Swedish utility OKG.

Following the Chernobyl accident, opinion polls in **Finland** showed strong public feeling against any futher nuclear expansion in that country. This reaction has created uncertainty about when or if a planned fifth and possibly sixth reactor will ever be ordered. Finland has maintained close ties to the Soviet Union and to the Soviet nuclear energy administration, and two of their four reactors were bought from the Soviet Union. The latest reports from Finland say that any nuclear plant orders are likely to be postponed until the mid-1990's. At present, it appears that coal could supply the majority of Finland's near-term energy needs. One Finnish state utility, Imatran Voima Oy (IVO), is reported to be considering several potential sites for coal-fired power plants.

Eastern Europe

In **Poland,** Parliament has reportedly been petitioned to stop construction on the Zarnowiec nuclear facility, after demonstrations attended by several thousand residents of Bialystok, a city near the site. Residents reportedly want the plant placed under IAEA supervision. The government has stressed that the four VVER-440 (PWR) reactors are of totally different design than the RBMK-1000 type at Chernobyl. Meanwhile, the government has reportedly chosen a site for Poland's second large nuclear complex, a sparsely populated site near Klepicz, in the Posnan region. The plans call for construction to begin in 1987, with a total eventual capacity of 4000 MWe.

Nuclear development in **Czechoslovakia** will continue unchanged, according to the Czech authorities. That country still plans a major expansion that would increase the share of nuclear generating power from 13.3 percent in 1985 to over 50 percent by the year 2000, as well as the development of a sizable engineering and manufacturing capability based on the Soviet VVER-440 design.

Activists in the **German Democratic Republic** (GDR) have submitted a call for a referendum that would halt nuclear construction. At issue are two 1000-MWe PWRs under construction at a site near Standal, in addition to the four 440-MWe PWRs near Lubmin.

In general, the governments of the countries in Eastern Europe state plainly their intention to continue with nuclear expansion plans. In most of these countries there is little organized opposition and few mechanisms to translate protest into policy change.

North America

In the **United States**, the Chernobyl accident does not appear to directly threaten US reactor operations. However, reaction to the Soviet disaster has focused attention on several nuclear issues:

1. Emergency preparedness and emergency planning zones (EPZ s). In past years, many in the US nuclear industry believed that the current 10-mile radius emergency planning zones were not only sufficient, but unnecessarily large. Prior to the Chernobyl accident, there was a movement to reevaluate the 10-mile zones, perhaps reducing the requirement to as little as two miles. At present there is little support for reducing the size of EPZs to less than 10 miles.

2. Types and designs of reactor containment structures. Since the Chernobyl accident, the types of containments used in various US reactor designs have become the focus of critical examination. Overall, the US nuclear industry has spent considerable time and effort to point out that pressure containment designs used on US reactors are adequate to ensure that radiation would not be released into the environment, even in the event of a core melt. However, the lack of containment structures at several non-commercial US reactors has attracted considerable criticism.

3. Reactors with design similarities to that of the Chernobyl reactor. Immediately after the Chernobyl accident, attention focused on the few reactors in the US with a graphite-moderated core design. The only commercial plant having a graphite core is

the Fort St. Vrain high-temperature gas-cooled reactor, operated by Public Service Company of Colorado. However, the graphite core material is the only design similarity this plant bears to the RBMK-1000 type at Chernobyl. (Several other non-commercial graphite-core reactors are in operation in the USA, but these units are not under NRC regulation.)

4. The Price-Anderson legislation currently under review in Congress. Liability limits for nuclear plants in the USA have recently attracted considerable public attention. During the last session of Congress, committees in the House of Representatives and the Senate were unable to resolve nuclear plant liability issues that affect an extension of the Price-Anderson Act (see article on page 25), which expires in August 1987. Currently the limit stands at $665 million dollars per unit. Legislative activity during 1987 is likely to result in the liability limit being raised to approximately $6.5 billion. In July 1986, the General Accounting Office released a study commissioned for the purpose of clarifying the question of liability limits under the Price-Anderson Act. It examined several scenarios whereby a number of US nuclear plants experience hypothetical "severe" and "catastrophic" accidents. The study compared potential damages arising from an accident in the USA in relation to the Chernobyl accident.

Critics of nuclear power in the USA have used the wide publicity given the Chernobyl accident to renew antinuclear efforts in the USA. However, the industry-wide safety reviews and the modifications applied after the accident at Three Mile Island Unit 2 in 1979 may have reduced the impact of the Chernobyl accident on public perceptions of the US nuclear industry. In general, controversial projects have been under scrutiny since before the Chernobyl disaster, and the reaction to it is not likely to result in the cancellation or shutdown of those plants.

In **Canada,** the completion of the last two units of the 3,500 MWe Darlington facility in Ontario is not likely to be affected by the event in the Soviet Union. However, Atomic Energy of Canada Ltd. (AECL) has spent considerable effort reassuring the public about safety-related matters, and emphasizing the important safety advantages of Canada's CANDU design over that of the Chernobyl reactor. The government of Ontario has, however, now approved distribution of potassium iodide pills to workers and residents living near nuclear plants. The debate over official approval has been going on since 1983, but has intensified since the Soviet accident. In a separate development, Ontario Hydro has prepared a proposal to provide nuclear safety technology to the Soviet Union, including training simulators, robotic devices, control systems, and radiation detection devices.

Far East

Despite considerable public concern over nuclear safety and increased opposition to the nuclear industry in recent public opinion polls, the government of **Japan** still holds to its original planning targets of increasing Japan's nuclear program as fast as possible. Start of construction of the Rokkasho-mura reprocessing plant could be delayed, however, while technology transfer agreements are still being negotiated and while the site selection is again analyzed for safety criteria. If budget requests from MITI (the Ministry of International Trade and Industry) and the Science and Technology Agency (STA) are approved for the fiscal year starting April 1, 1987, nuclear power may even increase its share of the Japanese government budget by 2.7 percent. The proposed budget for safety in particular has been increased considerably, up 14.2 percent, including much improved accident-related response and monitoring measures. In particular, the specific budget for severe accident-related safety measures was increased by 27.8 percent following the Chernobyl accident. Overall, most nuclear-related budget items are scheduled to receive an increase in funding, including research and development, although restraints imposed by Prime Minister Nakasone have resulted in a delay of the 600-MWe heavy-water demonstration reactor and budget cuts in the Fugen prototype reactor. However, only the increased attention to safety planning can be attributed to the Chernobyl event. Japan's intention to continue its nuclear expansion is officially unchanged, although site licensing procedures for new plants may have been slowed somewhat by a stricter application of regulations in response to public opinion.

The event at Chernobyl had little negative effect on **South Korea,** as indicated by the country's continued progress in two areas.

1. Korea's KNU-6, located at Kori, began commercial operations in June 1986, and KNU-7 started two months later. At present, there are six completed plants and Korea Electric Power Company (KEPCO) expects to produce at least 40 percent of the country's electricity from nuclear power in 1987.

2. After evaluating bids from a number of foreign nuclear suppliers, Korea awarded the contract for Korea Nuclear Units (KNU) 11 and 12 to Combustion Engineering (CE) in the USA. One of the reasons given for the choice of CE was the relatively higher degree of technology transfer involved in CE's bid; Korea's commitment to the attainment of self-sufficiency in the nuclear fuel cycle made that factor very important in the decision process.

Korea can be expected to proceed with its current construction plans. At present, three PWRs are under construction and in addition, planning and possible orders for KNU-13 and 14 are scheduled to take place in 1987. The pause in long-term nuclear planning in South Korea that has delayed planning and construction commitments for several more plants appears to be the result of revised projections in electricity demand, and not a response to the Chernobyl incident.

The long-delayed nuclear power plant in the **Philippines,** Philippines National Power Plant (PNPP Unit 1), is still the center of a political and public controversy. The plant's interest and construction costs are responsible for the largest single part of the Philippine's foreign debt, and are estimated to cost over $350,000 a day in interest alone. President Aquino supports a permanent closure of the facility, which has long been criticized for seismic and other safety-related matters. Now, following the Chernobyl accident, and mounting local opposition to nuclear power, the future of the plant and its operating license are again in question.

Taiwan has postponed at least until 1987 the planned reopening of tenders for its long-delayed units 7 and 8. Taiwan presently ranks third in the world in percentage of electricity produced from nuclear plants, with 53.1 percent in 1985. Although the postponement was partially attributable to the Chernobyl accident, it was at least equally the result of economic considerations. Nuclear power officials have decided to wait and add to a report that was being prepared on the state of nuclear power in Taiwan. This report's initial version has been reported by newspapers in Taipei to have been critical of the high cost of Taiwan's nuclear power strategy.

In the **People's Republic of China,** the reaction to the accident at Chernobyl has been difficult to determine. In March 1986, letters of intent were sent to the French reactor supplier Framatome to provide much of the plant hardware for the Daya Bay Project in Guangdong. Negotiations with joint-venture partner China Power & Light of Hong Kong have finally resulted in the September 1986 announcement of a signed agreement with Framatome, Electricite de France (EdF), and General Electric Co. of the UK. Since the Chernobyl accident, considerable public concern about the safety of nuclear power has arisen in Hong Kong, which is located only 55 kilometers from Daya Bay. Although that concern does not threaten the PRC's plans for its nuclear program, the Chinese authorities have begun a safety and environmental study, which they hope will calm the fears that have arisen in Hong Kong concerning plant safety and evacuation planning. The Ministry of Science and Technology in Beijing has also established a 25-member Safety Committee, authorized to oversee such areas as public safety policy, regulation, research, safety standards, and power plant supervision.

Other Countries

In **India,** government authorities stress that their commitment to a nuclear program is unchanged. Although they have called for studies to examine safety-related matters, India's largely domestic nuclear industry appears relatively unaffected by Chernobyl, despite several problems that have received media attention in recent months.

After the Chernobyl accident, **Greece** experienced considerable public concern over the increased levels of radiation received in that country. The government has reacted by dropping any plans to install nuclear facilities in that country. Whether this decision is directly related to the Soviet accident, however, or whether that event merely provided the catalyst is unclear. Instead, the government has announced that it will endorse a shift to a wind-power program for electricity production.

In **Egypt** the often delayed El-Dabaa reactor plan has again fallen behind in the bidding program, this time because of the Chernobyl accident and the perceived need for additional safety reviews that could lead to further requirements in plant design. The three bidders for this one or two-unit 900-MWe PWR order are consortia led by Kraftwerk Union, Framatome, and Westinghouse.

The controversy surrounding evacuation planning for **Brazil's** Angra Unit 1 plant, the only operating commercial nuclear reactor in Brazil, has intensified following the accident at Chernobyl. The restart of the plant, following an equipment failure in May, has been blocked by judicial proceedings that challenge the acceptability of evacuation plans for the nearby town of Angra Dos Reis. Brazilian government officials have tried to counter public concern by allocating funds to implement evacuation plans, and by promising to create a new government agency to oversee public safety matters. In mid-October 1986, however, the Federal Appeals Court in Brazil voted to allow the unit to restart. Full commercial operation of Angra Unit 1, brought on line in late 1984, remains behind schedule.

In spite of the Chernobyl disaster's effects on public opinion in Brazil, the government has decided to restart construction of Angra Unit 2, a partly completed Kraftwerk Union PWR, and has tentatively decided to keep in place plans for Angra Unit 3. The fate of Iguape Units 1 and 2, still under construction, is also in doubt.

There is little indication that the Chernobyl accident has affected **Argentina's** nuclear development. However, the country's slow economy and heavy debt situation have made low cost foreign financing of new nuclear plants a key issue. Argentina apparently wants to continue with plans to expand the role of nuclear power if financial obstacles can be overcome.

Brazil and Argentina have agreed to participate in a joint program in which each nation agrees to notify and assist the other in the event of a nuclear accident or radiological emergency. The Chernobyl accident appears not to have shaken either country's confidence in nuclear power, but it probably has contributed to a heightened awareness of safety and accident planning. Talks continue between Argentina and both the FRG and Canada concerning future orders of nuclear equipment.

Turkey's first venture in nuclear power, to be built at Akkuyu Bay on the Mediterranean, has been postponed, but not apparently by Chernobyl. Turkey's joint-venture negotiations with AECL of Canada have stalled over financing and other details rather than over safety concerns.

Startup of **Mexico's** Laguna Verde plant, Mexico's sole nuclear unit, has been long delayed, but is now expected early in 1987. Chernobyl has had less effect on the schedule than has Mexico's financial situation, particularly its large international debt. The Chernobyl accident has not played any significant role in the nuclear plans of either **Pakistan** or **South Africa.**

Conclusion

In most cases, present or future projects that have become centers of controversy after the Chernobyl accident were controversial long before that accident occurred. While Chernobyl has certainly had an impact, there have been few cases in which the Chernobyl accident has been the primary cause of a decision going against nuclear power. The Soviet disaster has, however, clearly limited the ability of many politicians to override or ignore their opponents on environmental issues. Particularly in some Western European nations, where governing majorities are created from fragile coalitions, the parties that oppose nuclear energy stand to gain in power to the extent that nuclear safety becomes a more important issue. Also, the nuclear debate after the Chernobyl accident has now affected many people who might not have been opposed to, or even very much aware of, nuclear issues. Generally, politicians who are pro-nuclear have been waiting quietly for the negative publicity to subside before trying to present their views.

The Chernobyl accident came at a time when reduced fossil fuel prices contributed to the feeling of having more energy options than were available only two or three years ago. This situation has allowed proponents of non-nuclear energy technologies to advance seemingly logical arguments in favor of non-nuclear alternatives. But the extent to which available nuclear-generated electricity acts to suppress demand for oil and coal, therefore holding down prices of these alternative fuels, has not yet been addressed carefully following the Chernobyl accident. As the economics are studied more thoroughly, the ease with which some politicians and parties advocate immediately shutting down nuclear power plants may well change.

© NUEXCO 1986

ESSAY

CHERNOBYL IN PERSPECTIVE

by

Donald P. Ebright

Managing Broker, Nuexco

Introduction

The far-reaching effects of the Chernobyl accident in the USSR have caused a great deal of controversy and anxiety worldwide, fueling the debate between pro and antinuclear interests. Observers have sought to learn as much as possible about the causes of the accident for a variety of reasons:

1. to establish how and why it happened;
2. to clarify what effects the accident had and will have on the world population, and
3. to examine what steps must be taken to prevent another accident.

Such a serious event understandably commanded international attention, but there has been little information presented by the news media that would place the exposures from the accident in perspective with risks to public health inherent in other means of power generation or everyday activities in the course of daily life. Unless the effects of the accident can be viewed in relation to other hazards, it will not be possible to make a balanced judgment about nuclear energy for electricity generation.

In the days immediately following the accident, few facts were available to the news media, and there were rumors that thousands of Soviet citizens had died. At that point, the international news media could do little more than report the various claims, although the USSR denied that widespread deaths had occurred. In time, it became evident that the initial reports of large numbers of fatalities were not true, but that there had been extensive contamination of the countryside surrounding the plant. Factual detail regarding the radiological conditions in the vicinity of the plant was limited, but radioactive fallout levels throughout western Europe were well documented. Understandably, those activity levels caused great concern to the citizens of western Europe and such information was widely publicized by the media. In fact, the exposures in western Europe were generally low, and much less than had been feared. However, the lack of concensus among national officials as to the interpretation of the inadequate data (in terms of meaningful or consistent exposure measurements) undoubtedly caused added confusion.

As a result, various antinuclear organizations throughout western Europe seized the opportunity to exploit the situation, aggressively pursuing their objectives to halt nuclear power programs and shut down nuclear plants. Many of those groups received inordinate amounts of publicity, usually without providing equal time or emphasis to those who tried to provide a more balanced view on the Chernobyl accident. A broad dissemination of a more balanced viewpoint could have done much to eliminate confusion and calm fears in the months following the accident.

Risks of Exposure

In late August, the USSR issued a detailed report on the accident before a group of experts in Vienna convening under the auspices of the International Atomic Energy Agency (IAEA). The symposium, involving the USSR, IAEA and nuclear industry scientists and engineers, has provided a wealth of information about the basic issues in the accident. From the data provided by the USSR, many conclusions have been reached regarding the causes of the accident and differences between the Chernobyl reactor type and those in operation in the West. However, there has been little information presented by the news media since the Vienna conference that would place the exposures from the accident in perspective with everyday risks to public health. In order to make a balanced judgment about nuclear energy, the effects of the accident must be viewed in relation to other hazards. This type of analysis does not diminish the seriousness of the Chernobyl accident, but can serve to minimize some of the overreaction fostered by a lack of balanced information.

The basic radiological exposures received or expected to be received by the Soviet population were taken from the official reports presented by the Soviet specialists at the IAEA meeting. Specific exposures received by people in western Europe will vary greatly as a function of meteorological conditions in the weeks following the accident (wind directions, amount of rainfall, etc.), time spent in open areas, differences in diets and eating habits, and the amount and source of imported foodstuffs. However, around the periphery of Europe, the total effective dose equivalent (EDE) *for the entire first year* after the accident, resulting from external, inhalation and ingestion exposure routes was calculated to be[1]:

— for adults, about 10 millirem;
— for children, about 25 millirem.

In the central portions of western Europe, the average EDE exposure results were calculated to be:

— for adults, about 60 millirem;
— for children, about 150 millirem.

Even in the more highly contaminated areas in the central portion of western Europe, the EDE exposure was calculated to be:

---

[1] *SOURCE:* World Health Organization (WHO) preliminary report, published in the September issue of *Nuclear Europe*.

© NUEXCO 1986

— for adults, about 130 millirem;
— for children, about 280 millirem.

In comparison, the average amount of radiation exposure received from natural background sources by a person living in a typically developed country at an elevation of about 1,500 to 2,000 meters (such as at Denver, Colorado) is about *250 millirem in a year.* Thus, on the average, the exposures received in western Europe over the first year after the accident at Chernobyl should be less than one would receive by living for one year in a high-altitude location.

To make another type of comparison, radiological exposure and medical effects of other, so-called "natural" causes of death, by cancer or other causes, have been extracted from Professor Bernard L. Cohen's publication, *Before It's Too Late — A Scientist's Case for Nuclear Energy.* The following data are limited to exposure predictions primarily for people in the immediate vicinity of the Chernobyl plant; similar data for other countries have not yet been formally presented. The exposure results for persons in other countries will be substantially lower due to the greater distances and lower concentrations of radioactive materials present from the accident. (This analysis disregards the large radiation exposures received by the personnel working in the Chernobyl plant and by the firemen who treated the resulting fires. Their exposures were excessive, resulting in about 32 fatalities to date.)

The Soviets report an estimated collective initial external exposure of 1.6 million rem to a group of about 114,000 civilians evacuated from areas around the Chernobyl plant. On the basis of the projection that an exposure of 8,000 rem to a large population group will eventually cause one extra death due to cancer, the above exposures would, over a lengthy period of time, equate to about 200 extra cancer fatalities. The Soviets concluded that for the target population group they could normally expect about 14,000 cancer fatalities over the next 70 years from "natural" causes. Thus, they estimate that the effects of radioactive fallout from Chernobyl might cause 280 cancer deaths in the affected group over and above those expected from other causes. That estimate of 280 extra deaths amounts to a two percent increase in the total expected cancer deaths for the target population group of 114,000.

The Soviets further concluded that for a larger group of citizens (75 million people), the collective dose during 1986 may be about nine million rem, and over the next 50 years, the collective dose may reach 30 million rem. By applying the same dose-to-cancer-fatality ratio as above, the 1986 exposure could eventually lead to about an extra 1,075 cancer cases; the 50-year exposure could result in an extra 3,625 cancer cases. By comparison, over about the same period, the Soviets estimate the natural frequency for cancer would lead to about 9.5 million cases. Thus, while not minimizing the seriousness of thousands of potential added deaths, the expected effects of Chernobyl on the population group involved would still be *less than 0.05 percent* of all cancer-related deaths.

Regarding exposures to the thyroid gland from radioactive iodine released by the accident, the Soviets calculate that the exposure may eventually result in about 1,500 extra cancer deaths, compared to 150,000 thyroid-related deaths from other causes over the same period. Thus, the Chernobyl effect is only about 1 percent of what would be expected normally.

In internal exposures following the accident, radioactive cesium is considered to carry the greatest risk of exposure arising from its presence in foodstuffs. From the ingestion of cesium, the Soviets calculate an exposure of about 200 million rem over the next 70 years. (Some US experts believe that this value may be high by a factor of ten from their interpretation of the fallout values.) However, this would lead to an increase of only about 0.4 percent in mortality rates arising from normal causes. Potential internal exposures from uptake of other radioactive isotopes in foodstuffs are not expected to exceed those from cesium, which is the chief cause of concern in this means of exposure.

The Risks in Perspective

In summary, estimates indicate that the number of additional deaths over the next 50 year period as a result of the Chernobyl accident could reach 10,000. That figure, while highly variable, is certainly disastrous, but is small compared to initial fears that deaths would number into the hundreds of thousands or even millions. For the rest of the world, the effects should only be a small fraction of 10,000. By comparision, in the USA alone, more than 10,000 people die prematurely *every year* from the effects of atmospheric pollution caused by the burning of coal for electricity generation, and at least 2,000 miners die each year from coal mining, transport of coal, or black-lung disease caused by coal mining.

To illustrate more graphically the magnitude of risk from a nuclear power plant or radiation, the loss in life expectancy (LLE) estimates probabilities of death associated with everyday activities. Those estimates are based on statistics applied to a large sample population. The LLE is the product of the probability of a risk to cause death, and the consequences in terms of lost life expectancy if it does cause death. For example, statistics indicate that in the USA an average 40-year-old male will live another 34.8 years, so if he takes a risk that has a one percent chance of being immediately fatal, it results in an LLE of $(0.01 \times 34.8) = 0.348$ years. Of course, this probability factor does not mean that he will die 0.348 years sooner as a result of taking this risk. Instead, if 1,000 males his age took this risk, one percent or 10 males might die immediately, having their

© NUEXCO 1986

lives shortened by 34.8 years, while the other 990 would not have their lives shortened at all by the consequences of their having taken the same risk. Hence, the *average* lost life expectancy for the 1,000 people would be 0.348 years (127 days) and 127 days is the LLE for that particular risk. Table 1 expands on this theory by projecting various large sample averages in terms of lost life expectancy.

Table 1

LOSS IN LIFE EXPECTANCY FOR VARIOUS ACTIVITIES[1]
(Based on large sample averaging)

Activity of Risk	LLE in Days
Being male vs female	2,800
Being unmarried	2,000
Cigarette smoking (1 pack per day)	1,600
Being 30 lbs. overweight	900
Driving small cars vs. standard size	50
Increasing driving speed from 55 to 65 mph	40
Working in a nuclear plant (Western world design) for entire lifetime	12
Radiation effects on the 135,000 Soviet people living within about 25 miles of the Chernobyl plant	10
Airline crashes	1
Dam failures	0.5
Radiation effects of living within a few miles of a nuclear plant of Western design for entire lifetime	0.4
Radiation effects on 75 million Soviet people living within a 300 to 600 mile radius of Chernobyl	0.4

[1] *SOURCE: Before It's Too Late — A Scientist's Case for Nuclear Energy*, by Bernard L. Cohen.

Conclusion

In light of these statistical averages, and the potential for major loss of life due to natural disasters such as dam failures, earthquakes, and other catastrophes, to conclude that Chernobyl was unusually costly in terms of human lives lost would be grossly erroneous. It also would be erroneous to conclude that all nuclear power plants should be shut down immediately or phased out within a short time because of concern over the Chernobyl accident. Decisions as to the types of systems used to generate electric energy should not be based on which system may have a smaller probability for a catastrophic accident, but on the *total number* of people whose deaths may be attributed to operation of the system in question. Professor Cohen's treatise explains this principle:

> "Suppose there are two technologies, A and B, for producing a desired product, and that technology A causes one large accident per year in which 100 people are killed, and that technology B kills 1,000 people each year, one at a time and unnoticeably. If technology B is chosen to avoid the catastrophic accidents from technology A, 900 extra people die unnecessarily each year."

It is clear that since Chernobyl, the world population has been exposed to varying degrees of additional radiation. However, it is also evident that for most of the world, including western Europe, the additional exposure generally has remained within the natural range of variation. Moreover, alternative means of generation of large quantities of electricity (by coal, oil, gas or hydro) may have greater adverse impact on the environmental ecology and health of the world population than does nuclear power. Thus, nuclear power should remain a preferred means of electricity generation for the vast quantities of electricity required today and in the future.

© NUEXCO 1986

SOUTH AFRICA

Third-quarter 1986 uranium production from Chamber of Mines producers totaled 2,906,000 pounds U_3O_8, a slight increase over the second quarter of 1986 (Table 2). While total production remained steady, several producers experienced declines, especially Harmony, JMS (Free State Joint Metallurgical Scheme), and Randfontein. Offsetting those reductions, Buffelsfontein increased production over 20 percent from their low second-quarter figures. Production at Buffelsfontein had fallen during the second quarter due to lower ore yield. Harmony Gold Mining Company Ltd. closed its Virginia plant at the end of August 1986 because of declining uranium demand and prices.

As one example of the South African producers' view of today's uranium market, Mr. C. G. Knobbs, Chairman of Harmony, made the following remarks in his annual review dated 28 August, 1986:

"The mine's production of uranium oxide dropped by 49,800 kilograms (110,000 pounds U_3O_8) reflecting the effects of the lower grade ore being mined. Some long-term supply contracts expired during the previous year, and with only two principal contracts left and some spot transactions, sales for the year dropped by 138,000 kilograms (300,000 pounds) or 34 percent. Nevertheless the drop in the value of the rand against the US dollar resulted in only a 12 percent decline in revenue compared with the previous year."

"Looking ahead, although a major upward price movement cannot be anticipated, the potential for some gradual improvement does present itself. The massive readjustment in the strength of the US dollar during the 1985 financial year has lowered the spot price for natural uranium to its lowest point in five years in terms of Yen and Deutschmark, the currencies of the more important purchasers. This trend should encourage purchases and render less attractive the practice of inventory liquidation which led the downward spiral in prices in the recent past. Unless any new major sources of supply enter the market this should allow for some price improvement in the near term."

"Uranium sales revenue will increase somewhat in the coming year in filling long-term contractual arrangements. These contracted sales, together with the anticipated spot sales, will nevertheless be insufficient to justify the operation of both the Harmony and Virginia uranium plants. International sanctions against South African uranium can only exacerbate the position. Serious consideration must therefore be given to closing another plant. The Merriespruit uranium plant was closed in March 1984."

Table 2

REPUBLIC OF SOUTH AFRICA:
1986 URANIUM PRODUCTION[1]
(Thousands of pounds U_3O_8)

Operation	First Quarter 1986	Second Quarter 1986	Third Quarter 1986	Year to Date 1986
Buffelsfontein	353	300	362	1,015
Driefontein Consolidated	41	49	46	136
ERGO[2]	91	88	79	258
Harmony	231	211	171	382
Hartebeestfontein	238	264	267	769
JMS[3]	318	305	279	902
Randfontein	339	324	304	967
Stilfontein (Chemwes)	137	135	141	413
Vaal Reefs	1,082	1,069	1,107	3,258
Western Areas	155	147	150	452
TOTAL[4]	2,983	2,892	2,906	8,871

[1] Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.

[2] ERGO = East Rand Gold and Uranium Company Ltd.

[3] JMS = Free State Joint Metallurgical Scheme.

[4] Columns may not add due to rounding.

SWITZERLAND

The debate over the future of nuclear power in Switzerland continued last month as the Swiss Parliament examined various resolutions concerning energy policy in general and nuclear power in particular, following the Chernobyl accident. Following extensive discussion, the lower chamber of the Federal Assembly defeated by a vote of 105 to 68 a motion to shut down all Swiss nuclear power stations. Concurrently, the upper chamber voted unanimously to commission a study by the executive branch and review its recommendation. The study will focus on the future of energy sources and the consequences of replacing nuclear power with other sources of electricity. Switzerland presently generates about 60 percent of its electricity from hydropower, and about 40 percent from nuclear power.

The voting in the lower chamber was split between the Social Democrats, who are opposed to nuclear energy, and the Radicals, Christian Democrats, and Liberals, who are generally in favor of nuclear power. After an in-depth discussion of energy policy, the assembly voted in favor of continuing Switzerland's nuclear power program, concluding that without nuclear power only three alternatives would be available to supply the energy needs of the country:

1. Conservation measures;

© NUEXCO 1986

2. Other sources of electricity generation;
3. Importing electricity from neighboring countries.

Substituting additional hydroelectric stations for the nuclear power plants would require damming many more rivers, which has become unpopular with the Swiss people. In addition, such a plan would place a greater reliance on hydropower than would be compatible with the Swiss desire for a well-distributed energy mix. The debilitating environmental effects of coal or oil-fired power stations, and the lack of those indigenous resources, make electrical generation from fossil fuels unpopular. Finally, Switzerland's desire for energy autonomy makes the importation of power from other countries an undesirable alternative.

The lower chamber also voted 101 to 72 to continue development of the Kaiseraugst nuclear power plant project. In March 1985, the government granted a general authorization to proceed with the project. However, the vote to continue development of Kaiseraugst does not preclude the possibility of a moratorium on construction imposed at a later date Bid evaluation for the new plant is underway. The consortium that owns the project includes seven Swiss utilities, three Swiss industrial groups, the French utility Electricite de France, and two West German utilities, RWE and Badenwerk.

Ultimately, despite the vocal protests over nuclear energy following the Chernobyl accident, the Swiss Parliament's affirmation of the role of nuclear power in that country represents a positive signal for the future of European nuclear power programs.

UNITED STATES

The US Congress, in an unexpected move, failed to disapprove the new enrichment criteria that DOE proposed on July 24, 1986. Although separate joint resolutions were passed in the Senate and House of Representatives to disapprove the criteria, Congress was unable to attach the resolutions to any pending legislation. One resolution had been attached as an amendment to a virtually veto-proof debt reduction bill, but the bill was stripped of all amendments immediately prior to its passage.

However, Congress did succeed in effectively nullifying those sections of the new criteria that had caused the most controversy by passing a joint resolution with the following introduction:

"None of the funds provided in this joint resolution or in any other law may be used to implement the following provisions of the uranium enrichment criteria submitted to Congress on July 24, 1986."

In effect, the resolution provides for funding of the new criteria, *except* for five important sections. Those sections denied government funding (effectively making them difficult to implement) are the following.

1. "Section 762. 3, which specifies the permitted enrichment of source material of foreign origin for use in domestic utilization facilities."

2. "The third sentence of section 762.11 (pertaining to quantities and form of feed and product material), to the extent that it provides limitations on free choice of transaction tails assays from 0.2 to 0.3 w/o U_{235} or imposition of an additional charge for selections in that range." In other words, DOE must provide a free Variable Tails Assay Option (VTAO).

3. "Section 762.15 (pertaining to prior enrichment contracts), to the extent it might be construed to validate contract provisions permitting unrestricted delivery and enrichment of foreign-origin feed material after a final court decision requiring restriction(s)...or permitting imposition of additional charges" for the VTAO. In other words, DOE cannot implement this section in order to circumvent a court decision requiring foreign-origin uranium restrictions or a VTAO surcharge.

4. "Any portion of the criteria or provision in any contract which permits or results in a reduction of the amount of feed material otherwise required to be delivered to DOE by commercial customers as a result of the use of uranium from government stockpiles...", i.e., the practice of over-feeding from the DOE stockpile.

5. "Section 762.6 (*Recovery of Prior Unrecouped Government Costs*), insofar as it may convey a determination of the level of unrecouped costs that must be returned to the Treasury by the enrichment program, which determination shall be made by the Congress in future legislation." Thus, the issue of the size of DOE's enrichment debt will be postponed until Congress reviews it again, apparently in its next session, which begins in early 1987.

In essence, by withholding funding for those sections, Congress stripped the criteria of the most controversial provisions. Congress appears intent on studying the cost recovery issue further, rather than allowing DOE to establish prices and costs based on its determination of the enrichment debt. In effect, the Utility Services Enrichment Contract (USEC) was partially approved by the resolution, but those provisions of the contract relating to foreign-origin enrichment, the free VTAO, and over-feeding from the DOE stockpile were not approved. As far as the question of enrichment of foreign-origin uranium for US use, Congress specifically stated that the issue was to be decided entirely by the outcome of the DOE/US producers litigation, currently under appeal in the Tenth Circuit Court of Appeals:

"...foreign-origin uranium may be enriched for domestic use only until a final judgment or dismissal in the pending litigation that determines whether section 161(v) of the Atomic Energy Act requires restriction of enrichment of foreign-origin source material, in which case the criteria shall be amended to impose such

© NUEXCO 1986

restrictions, or such unrestricted enrichment may continue, whichever is consistent with the decision of this question in the pending litigation..."

Thus, Congress will not allow DOE to use the new criteria to circumvent the decision that will be made by the Tenth Circuit Court regarding restrictions of foreign-origin uranium. Moreover, Congress made it clear that its joint resolution should have no impact on the court's upcoming decision:

"No provision of this joint resolution or the July 24, 1986 criteria shall affect the merits of the legal position of any of the parties...in the pending litigation in the United States Court of Appeals for the Tenth Circuit..."

As to the aforementioned litigation, there were no developments during October. If a decision is made by the Circuit Court of Appeals that effectively upholds the District Court ruling in favor of the producers, DOE would have no further *right* of appeal. However, DOE could petition the US Supreme Court to review the case. At that point, such a review could be granted or denied by the Supreme Court.

* * *

An article in Report 214 (June 1986, page 16) outlined the terms of some proposed changes to Statement of Financial Accounting Standard No. 71, entitled, "Accounting for the Effects of Certain Types of Regulations." Nuexco has been and will continue following the developments in this issue, as changes in the accounting treatment of certain events such as disallowances and plant cost phase-ins for electric utilities could have a strong impact on future nuclear plant financing or on recovery of costs through ratemaking. Recently, the *Wall Street Journal* reported that the Financial Accounting Standards Board (FASB) approved in part a new accounting standard pertaining to utility accounting methods for disallowances and other ratemaking issues. However, when contacted by Nuexco, a spokesman for FASB stated that the Board was still considering the amendment to Standard No. 71 and the comments to its Exposure Draft, and that a decision might not be reached until December 1986.

CORRECTION

The article on the Olympic Dam Project in Report 218 (October 1986) stated that the development schedule for the project calls for annual production of 5.2 million pounds of U_3O_8. In actuality, the schedule calls for annual production of 2,000 metric tons U_3O_8, or *4.4* million pounds U_3O_8.

© NUEXCO 1986

FOCUS

THE PRICE-ANDERSON ACT

Introduction

During the recently adjourned session of the United States Congress, committees in both houses of Congress worked to produce draft versions of an extension to the Price-Anderson Act. Congress, however, did not vote on this bill before adjournment. The Act, passed by Congress in 1957 to ensure that victims would be compensated in the event of an accident involving a commercial nuclear reactor or its radioactive elements, basically provides for what is in effect a joint private sector and government insurance policy for US nuclear utilities. Unless amended and extended by Congress, it will expire on August 1, 1987. Even if no legislative action is taken by the expiration date, all commercial reactors under license by the NRC at that date will still be covered at the original limits. However, after the expiration date, any new commercial reactors would not be covered under the Price-Anderson Act's authority, and contractors and their subcontractors operating facilities for the Department of Energy (DOE) would no longer be covered upon termination of their contracts.

Current Status

The main provisions of the Price-Anderson Act are summarized below.

1. It provides for private insurance and an insurance-like fund that is to be used to satisfy claims for personal injury and property damages to the public arising from a nuclear accident at any commercial US nuclear reactor.

2. The insurance also covers accidents arising from transportation of nuclear fuel and waste to and from reactor sites, as well as storage of nuclear fuel and waste at reactor sites. In addition, coverage is provided for nuclear-related accidents occurring at DOE contract facilities.

3. Claims made in case of accidents are to be settled under a system separate from the various state civil tort systems, and compensation and awards can be paid more promptly, avoiding lengthy litigation in local courts.

4. Utilities operating commercial reactors rated at over 100 MWe are obligated to carry the maximum available private liability insurance, currently $160 million per reactor. In addition, if the ultimate liability exceeds the $160 million in coverage, utilities operating nuclear reactors have to contribute up to $5 million per reactor into a pooled fund to be used to defray the balance of the liability. For damages beyond the liability limit, Congress is authorized to consider the payment of additional funds by the US government.

Thus, under the terms of the Price-Anderson Act, liability may be shared collectively among operators of nuclear power plants. At present, the nuclear industry's overall liability limit (the total compensation fund available for a nuclear accident) stands at about $665 million. This figure is derived from the utility's private insurance coverage on the involved reactor ($160 million) together with the retrospective maximum premium of $5 million assessed to each operating reactor, assuming 101 operating reactors having over 100 megawatts rated capacity.

In a very general sense, the Price-Anderson Act is intended to provide a measure of financial protection from nuclear incidents occurring across a broad spectrum of activities, and not just from accidents occurring during generation of electric power from commercial nuclear plants. Nuclear materials in the form of nuclear fuels are included under the Act, whether being transported to or from a facility using them, or in storage at a facility. Byproduct material, such as high and low-level nuclear waste, is also covered during transportation and storage, as are special nuclear materials, such as radioisotopes used in medicine or medical research. The many different licensees and contractors who are authorized to conduct nuclear-related activities, such as agencies or laboratories operating research reactors, or facilities handling nuclear waste material, also come under the jurisdiction of the Price-Anderson Act.

Another important feature of the Act is the separation of its damage claims procedures from the tort (civil lawsuit) system. The Act provides a mechanism whereby lawsuits for personal injury or property damage shall be presented and settled independently of the local legal system. One aspect of this provision replaces the often short periods of time within which an injured party must pursue his claim as established by state statutes of limitation. The Act currently provides for a maximum 20 year statute of limitation. In general, the procedures under the Price-Anderson Act are designed so that claims will be settled more quickly and simply than by litigation under state tort law.

The most controversial provision of the Price-Anderson Act concerns the liability limit with respect to a nuclear accident. Presently, an operator cannot be held liable for damages beyond the total amount available in the insurance pool, or about $665 million. However, provisions of the Act require Congress to review those situations in which actual damages exceed the liability limit. Such a review could result in authorization of additional funds to be provided by the US government for accident victims. The liability limit has the effect of placing the assets of the public utility beyond the reach of persons with damage claims in excess of the insurance coverage. In the event of an accident in which damage claims exceed the liability limit, the operating company is able to protect most of its assets from lawsuits that might otherwise bankrupt the company.

Recent Actions

The Chernobyl accident substantially increased the public's perception of the total damages that might be caused by a nuclear reactor accident. Before the Chernobyl disaster occurred, estimates of probable damages caused by nuclear accidents tended to be considerably lower than they are now. The accident at Three-Mile Island Unit 2, for example, involved little off-site damage; i.e. damage of the type that would produce claims under the Price-Anderson Act. The Chernobyl accident, however, showed that an "extraordinary nuclear occurrence", the phrase used in the Act to describe an accident involving substantial off-site contamination and damage, can occur.

In July 1986, the General Accounting Office released a study that estimated a range of damages that could result from a catastrophic accident at a US nuclear reactor. The study estimated off-site damages at several reactor sites at between $300,000,000 and $15,000,000,000. Using those figures the study indicated that the probable damages at a majority of US reactors would be about $6 billion. Using the study's estimates and the current $665 million limit, only about 4 percent of operating plants would be considered as fully covered by Price-Anderson funds.

The debate over the Price-Anderson Act has been extensively reported for the last few months, as different versions of legislation have been written in five separate Congressional committees. In the House of Representatives, the Energy and Commerce Committee, the Interior and Insular Affairs Committee, and the Science and Technology Committee have all worked on the bill. In the Senate, the Energy and Natural Resources Committee and the Environment and Public Works Committee have also produced drafts of an extension. During the next session of Congress, certain compromises will have to be reached on the several issues still dividing legislators in the various committees if an extension is to become law.

Key Issues

1. *Liability limits:* It is likely that the liability limits will be increased when the Price-Anderson Act is eventually amended and extended. In Congressional debate, limits discussed have ranged from about $2.5 billion up to a removal of all limits on liability. Realistically, the limit probably will be raised to a level between $5 and $6.5 billion. Any provision that allowed unlimited liability would be unacceptable to the nuclear industry, which only reluctantly supports a proposal for a limit in the range of $2-3 billion. Raising the liability limit to $6.5 billion would set each 100-plus megawatt reactor's total liability for retrospective premiums at about $63 million per accident, instead of the current $5 million. Under Representative Morris Udall's proposed compromise, the $63 million premium would be paid in annual installments not to exceed $10 million per year. In addition, increased primary private insurance coverage up to amounts available from the insurance industry (estimated at $200 million) might be required (up from the present figure of $160 million).

2. *Plant operators vs. DOE licensees:* Utility companies operating reactors and contractors to the Department of Energy represent different parts of the liability problem. DOE contracts with operators at four major research facilities — Los Alamos National Laboratory, the Hanford Reservation, Lawrence Berkeley Laboratory, and Lawrence Livermore National Laboratory — expire at the end of September 1987. Without the coverage provided by the Price-Anderson Act, contract negotiations at these and other DOE facilities could be difficult. In one proposed version of the extended Act, the first $6.5 billion in damages incurred by DOE contractors would be paid from the nuclear waste fund, with no limit to the federal government's liability. In other versions, liability limits of from $2.2 to 6.5 billion would be imposed. Any bill that would make the government fully liable for accidents by DOE contractors would likely be vetoed by the President.

3. *Indexing for inflation:* Some versions of the proposed Price-Anderson Act extension include provisions for automatically indexing the liability limits to inflation, perhaps every five years. Any indexing that would increase the limits over time is strongly opposed by the nuclear industry.

Conclusion

The viewpoint of the nuclear industry concerning the Price-Anderson Act has been one of caution, especially after the accident at Chernobyl. The single best argument in favor of low liability limits, one stressing the nuclear industry's safety record, suddenly lost much of its force. The industry clearly hopes for a low limit on liability and opposes indexing for inflation, but there seems little point in fighting for the lowest possible figure while the Chernobyl disaster still affects most nuclear-related issues before Congress.

Groups opposed to nuclear power also would not be entirely satisfied with a $6.5 billion limit on liability, even though it would represent an increase of nearly ten times the present limit. Many of these groups support unlimited liability or limits well above $6.5 billion, citing studies that estimate the potential damages from a major accident near a heavily populated area at up to $300 billion.

Congress has now adjourned until January 1987 without voting on a Price-Anderson Act extension or amendment. It seems likely that the Act will reappear before the next Congress in essentially the same form, although perhaps focusing on the issue of coverage for DOE contractors rather than on the issue of liability limits for commercial plants. In any event, nearly all parties are agreed on the desirability of extending the Price-Anderson Act.

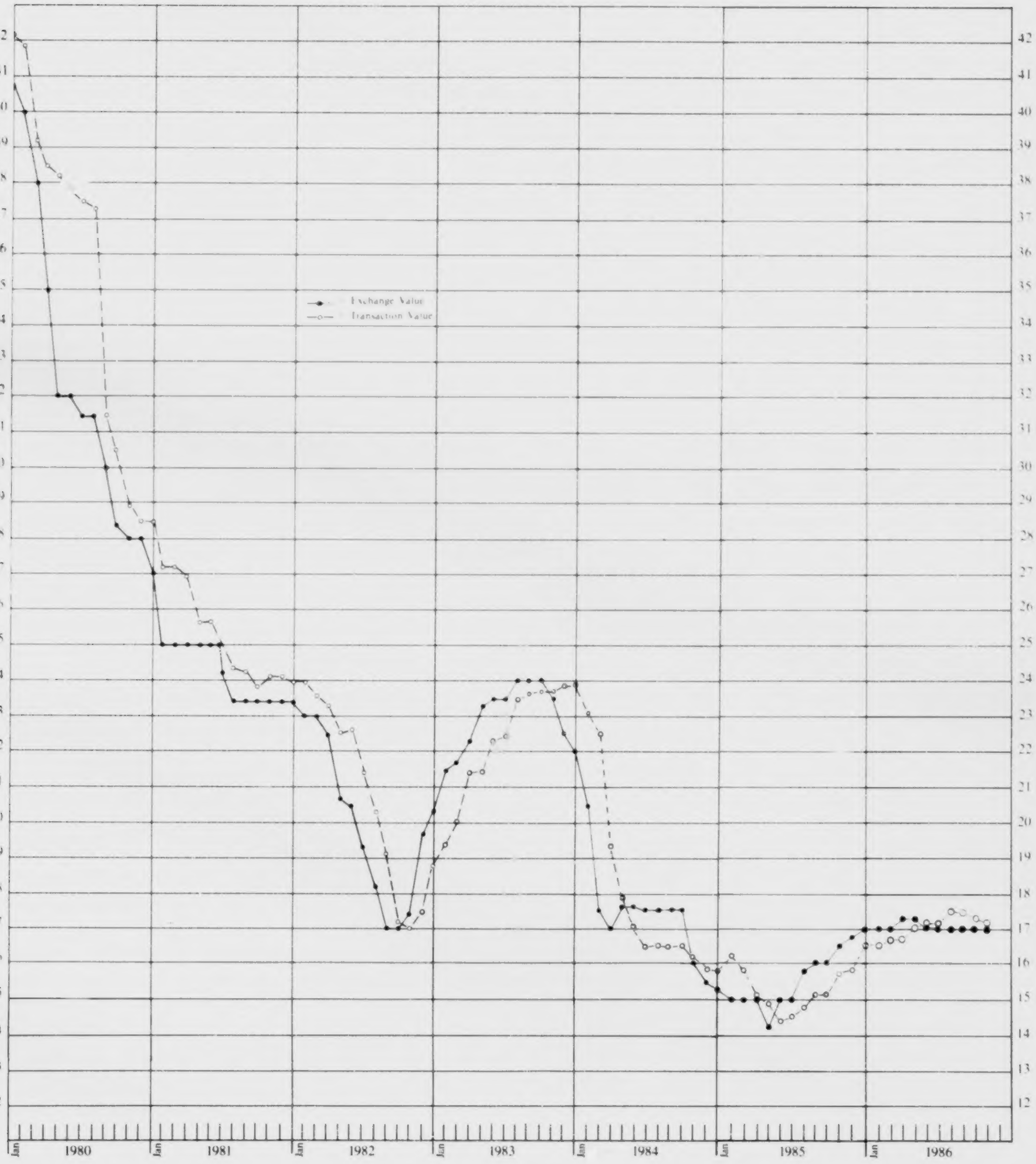
© NUEXCO 1986

NUEXCO

HISTORICAL MARKET DATA

EXCHANGE AND TRANSACTION VALUES SINCE JANUARY 1980

Determined as of the last day of the month indicated



© NUEXCO 1986

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	32.50	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	**17.00**		

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	**17.25**		

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	**1.90**		

© NUEXCO 1986

GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3,4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7R	202.5
Oct 1985	108.4R	202.4
Nov 1985	109.4R	209.9
Dec 1985	110.0R	210.0
Jan 1986	109.6R	210.0
Feb 1986	108.7R	210.0
Mar 1986	99.5R	210.5R
Apr 1986	94.3R	210.5R
May 1986	93.5R	210.5R
Jun 1986	95.7R	210.5R
Jul 1986	98.1	215.2R
Aug 1986	—	215.2

P = Preliminary R = Revised since last month

[1] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4] Annual averages prior to 1979 reflect index base no longer in use.

[5] Monthly data for 1979-82 appear on page 35 of Report 184.

[6] Annual averages are for financial year ending June 30.

© NUEXCO 1986

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	Primary Non-ferrous Metal Industries[4] (SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.4	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.5R	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.7R	19.80	16.63	15.64R	13.44R	11.86R	12.49R
Jul 1986	118.7R	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1P	18.96P	16.13P	15.40P	12.97P	11.78P	12.74P

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637R	462,365R
Jul	1986	—	—	228.8	216.3	765,915	520,983
Aug	1986	—	—	232.2	220.3	—	—
Sep	1986	81.94P	181.8	236.7	—	—	—

---

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria, "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1986

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6R	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.6	298.9	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.7	328.0	—	13.47	13.22	12.04R	9.63
Aug 1986	307.7	297.2	328.6	—	13.14P	13.25P	11.98R	9.67R
Sep 1986	308.8	297.7	330.2	115.0P	—	—	12.03P	9.74P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

© NUEXCO 1986

NUEXCO

REPRESENTATIVES AND CONSULTANTS

JAPAN

Kazy Yokota

Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson

Southern Prospecting (Pty) Limited
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telephone: (27-11) 838-1868
(27-11) 834-4211
Telecopy: (27-11) 834-3148
Telex: 4-89878 SA

TAIWAN

Edward Bee

Bee & Liang Company, Ltd.
14 Fl. Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg

83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

Ralph O. Smith

141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

SPECIAL CONSULTANTS

George J. Stathakis
International Investment Banking

James C. C. Stewart
U.K. Nuclear Industry

W. Bryan Webster
International Business Development

J. Robert Wolcott
International Business Development

NUEXCO

EXECUTIVE SUMMARY
REPORT 219

(All data as of October 31, 1986)

Exchange Value $17.00, unchanged	The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month.
UF_6 Value $48.00, unchanged	The **UF_6 Value** is **$48.00** per kilogram U as UF_6, unchanged since last month.
Transactions	**Six** recent natural uranium sales are reported, involving approximately **1.0 million** pounds equivalent U_3O_8. All of the sales involved spot or near-term delivery, and all met the conditions for inclusion in the Transaction Value. Four of the transactions involved natural UF_6.
Supply-Demand Ratio increased to 3.9:1	Active spot and near-term **uranium supply** amounts to **3.7 million** pounds U_3O_8 equivalent, down 310 thousand pounds since last month. Active spot and near-term **uranium demand** totals **1.0 million** pounds, down 465 thousand pounds. The spot and near-term **supply-demand ratio** increased to **3.9:1.**
Transaction Value $17.25, down $0.10	The **Transaction Value** is **$17.25** per pound U_3O_8, down $0.10 since last month. The calculation includes 13 transactions involving a total of 2.4 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.
Loan Rate unchanged at 4%	The **Loan Rate** is **4 percent** per annum, unchanged. One natural uranium loan transaction is reported.
Conversion Value $1.90, unchanged	The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 2.0 million pounds U as UF_6. Active demand totals 650 thousand pounds U as UF_6. No secondary market conversion transactions are reported.
SWU Value for delivery within one year: $78, unchanged	The **SWU Value** at .3 tails and for delivery within one year is **$78** per SWU, unchanged since last month. Three secondary market SWU transactions are reported involving approximately 100 thousand SWUs.

* * *

Analysis and Commentary	Six months after the April 1986 accident at Unit 4 of the Chernobyl station in the USSR, worldwide public reaction has subsided and the likely effects of the accident appear to be far less severe than originally projected. This article examines the effects of Chernobyl on the international nuclear industry, discussing political positions taken since the accident, and possible changes in plans for additional nuclear facilities.
Essay	Nuexco Managing Broker Donald P. Ebright discusses the need for balance and perspective in evaluating the radiological dangers associated with the Chernobyl accident and its effect on public perceptions of nuclear power.
South Africa	Chamber of Mines producers report third-quarter uranium production of 2,906,000 pounds U_3O_8, a slight increase over second-quarter 1986 production. As a result of lower-grade ore and adverse economic conditions, Harmony Mines closed its Virginia uranium plant.
Switzerland	The lower house of the Swiss Parliament has rejected a motion that would have called for the shutdown of all of the country's nuclear power stations.
United States	The US Congress unexpectedly approved DOE's new enrichment criteria issued in July, but the Congress prohibited government funding for the most controversial sections of the criteria, including those concerning the enrichment debt and the enrichment of foreign uranium.
Focus	The Price-Anderson Act, which provides liability insurance in case of an accident involving a US nuclear plant, has been publicized of late because of Congressional attempts to amend the act and extend its coverage period. The key issues of the thirty-year-old legislation will be reviewed when Congress reconvenes in 1987.

This Executive Summary may be reproduced for internal distribution.

© NUEXCO 1986

NUEXCO

NUEXCO REPORT 219 FIGURES OF THE MONTH (October 31, 1986)	This Month (Report 219)	Last Month (Report 218)	12 Months Ago (Report 207)
Exchange Value[1]	17.00	17.00	16.50
Transaction Value[1]	17.25	17.35	15.75
UF_6 Value[2]	48.00	48.00	46.00
Loan Rate[3]	4%	4%	5%
Conversion Value[4]	1.90	1.90	1.60
Near-Term Uranium Supply[5]	3.7	4.1	3.2
Near-Term Uranium Demand[6]	1.0	1.4	0.9
Near-Term Supply-Demand Ratio	3.9	2.9	3.6
Recent Uranium Sales:			
Number of Transactions[7]	6	4	5
Quantity of Material[8]	1.0	0.5	1.4
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	78	78	—
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Market Value of Enriched UF_6[13,14]:			
2.5 w/o U_{235}	458	458	460
3.0 w/o U_{235}	586	586	591
3.5 w/o U_{235}	717	717	723
4.0 w/o U_{235}	849	849	858

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used in the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[14] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (218)

Topic		Page
Pricing	Continuing Decline in Spot Uranium Prices in European and Japanese Currencies	3
Basic Considerations	The Tails Assay Swap	13
South Africa	AEC Released Biennial Uranium Industry Report	16
United States	South African Uranium Imports Prohibited	16
Raw Materials	The Olympic Dam Project: Progress Report	19
Nuclear Fuel Pricing	*Natural Uranium and Conversion* Pricing in September 1986	1
	Enriched Uranium and SWUs Pricing in September 1986	2

© NUEXCO 1986

12/17/86 86800-1 A

NUEXCO

DECEMBER 1986 NUMBER 220

MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

Three Park Central 1515 Arapahoe Street, Suite 1045 Denver, Colorado 80202

HEADQUARTERS

Chairman of the Board of Partners
Oren L. Benton

Vice Chairman of the Board of Partners and Chief Executive Officer
Samuel R. Freeman

Directors of Operations
Business and Financial Affairs — James E. Lewis
Administration — J. Fred Lawrence
Legal and Regulatory Affairs — Frederick J. Boyne

NUEXCO FUEL BROKERAGE SERVICES

Manager of Fuel Brokerage
Earl E. Hoellen, Jr.

BROKERAGE SERVICE LOCATIONS

UNITED STATES

DENVER
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

Managing Broker
Earl E. Hoellen, Jr.

MENLO PARK
Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

Managing Broker
George White, Jr.

EUROPE

FERNEY-VOLTAIRE
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

Managing Broker
James E. Vaughan

ZÜRICH
135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

Managing Broker
Donald P. Ebright

REGIONAL MANAGING BROKERS

AFRICA
James E. Vaughan

AUSTRALIA
George White, Jr.

FAR EAST
Earl E. Hoellen, Jr.

NORTH AND SOUTH AMERICA
Earl E. Hoellen, Jr.

(See inside back cover for list of Representatives and Consultants.)

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

December 1986 No. 220

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 7

ANALYSIS AND COMMENTARY

Australia's Supply Position 11

BASIC CONSIDERATIONS

Germany's THTR 300 and the High-Temperature Reactor Program 14

RECENT DEVELOPMENTS

United States 18

RAW MATERIALS

Solution Mining of Uranium, Part 1 20

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 24
Historical Exchange Value, Transaction Value and Conversion Value 25

GOVERNMENT STATISTICS

Australia 26
Canada 27
South Africa 28
United States 29

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein.

© NUEXCO 1986

To Our Readers

We are pleased to announce that **Mr. Charles B. Lewis** has joined Nuexco to assist Wes Miller with the production of the Monthly Report. Charlie has over ten years of experience in technical writing and engineering, and in the early 1970s served in the Peace Corps in Thailand. He holds a B.A. in English Literature from Lewis and Clark College and an M.A. in East Asian Studies from Stanford University, and speaks Chinese, Thai, and Spanish. He will be relieving Clark Beyer, who will be involved in brokerage operations in the USA and Canada. Clark has been the Associate Editor of the Monthly Report for the past two years.

* * *

Beginning in this issue of the Monthly Report, we are adding European Currency Units (ECU) to the tables showing the Nuexco Market Values expressed in selected producer and consumer currencies. The ECU is a composite currency of the ten national currencies of European Economic Community nations. In 1979, the EEC members formed the European Monetary System, and designated the ECU as its official currency.

The ECU is formed by incorporating fixed percentages of each currency — for example, the West German Deutschemark comprises 32.24 percent of the ECU composite. The relative weight carried by each currency can also vary depending on the exchange rates of the individual units. On a daily basis, the EEC estimates ECU value against the various member currencies, as well as against the US dollar and Japanese yen.

* * *

© NUEXCO 1986

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of November 30, 1986)

The **Exchange Value** is **$16.75** per pound U_3O_8, down $0.25 since last month. **Active supply** of nautral uranium (concentrates and UF_6) for spot or near-term delivery totals **4,530,000** pounds U_3O_8 equivalent, up 790 thousand pounds since last month. The corresponding figure for **active demand** is **770,000** pounds, down 180 thousand pounds. The spot and near-term **supply-demand ratio** increased to **5.9:1.**

The *Current Market Data* section of this Report lists six natural uranium sales, involving approximately 750 thousand pounds U_3O_8 equivalent in the near term and five million pounds U_3O_8 equivalent in the longer term. Five of the transactions involved spot or near-term delivery, and four met the criteria for inclusion in the current Transaction Value calculation. Four of the transactions involved natural UF_6.

The **Transaction Value** is **$17.30** per pound U_3O_8, up $0.05 since last month. The calculation extends over a 3-month period and includes 13 transactions involving 2.0 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$48.00** per kilogram U in UF_6, unchanged since last month.

The **Conversion Value** is **$1.80** per pound U in UF_6, down $0.10 since last month. Active supply of secondary market conversion services for delivery within three years totals 1.4 million pounds U as UF_6. Active demand totals 650 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **4 percent** per annum, unchanged.

* * *

The Exchange Value declined $0.25 to $16.75 this month. During November some sellers demonstrated a willingness to drop below $17.00 in their asking prices, and one transaction involving a relatively large quantity of non-US concentrates was concluded at a price near the current Exchange Value. Demand for natural uranium concentrates remained thin, declining about 20 percent since October to less than 800 thousand pounds equivalent U_3O_8. Sellers are also offering more natural uranium than last month. Supply increased by 20 percent, so the supply/demand ratio increased from 3.9 to 5.9.

The market for natural UF_6 was stable during November, and the UF_6 Value remained unchanged at $48.00. Overall, demand for UF_6 is somewhat greater than demand for U_3O_8, and significant quantities of non-US UF_6 are still available at prices around $48.00.

The market for uranium continues to reflect the uncertainties surrounding the lawsuit filed by three US producers against DOE. Although some observers had expected a ruling from the Tenth Circuit Court of Appeals to be handed down by the end of November, no such ruling has yet been made. Rumors that the court's ruling will be favorable to US producers appear to be partly responsible for the increasing competition among sellers, chiefly Canadian producers. As a result, significant quantities of natural uranium concentrates are being offered for sale at or below $17.00. Pending a resolution of this lawsuit, most discretionary buyers remain unwilling to commit to additional purchases at this time.

A letter from several members of Congress to President Reagan has refocused attention on the issue of how the US ban on the importation of South African uranium will be implemented. Because the law refers only to uranium oxide and uranium ore, some have argued that a literal interpretation would allow the importation of UF_6. However, the authors of the letter, including those members of Congress who sponsored the bill, emphasized that the legislation was clearly intended to prohibit the importation of any uranium of South African origin, regardless of form. South African origin UF_6 probably would have been included in the ban anyway, but the letter has made that result even more likely. The letter failed to address the question of whether the legislation would allow the importation of South African uranium solely for the purpose of processing and subsequent export to non-US utilities. Ultimately, the resolution of both issues will depend on the Reagan Administration's interpretation of the law. (For additional background on this issue, see page 16 of Report 218 [October 1986]).

The possibility of restrictions on the usage or enrichment of non-US origin uranium remains the most important single factor influencing the market. However, of the US utilities in the market or entering into transactions over the last several months, only about half specifically requested or ultimately contracted for US-origin material. Some US utilities have contracted for non-US uranium in order to feed it into the enrichment pipeline before possible limitations are enacted.

US-origin material currently commands a premium of $0.65 per pound U_3O_8 in the form of concentrates, and $2.50 per kilogram U in the form of UF_6. A few concentrate sales by US producers have included premiums near that amount, but most of the US-origin material sold in the last several months has been made available by means of origin-swap mechanisms. The utilization of such swaps has allowed US utilities to purchase US-origin material without having to pay most US producers' substantially higher asking prices.

* * *

The Conversion Value fell this month to $1.80, and demand remains thin. The secondary market remains largely inactive, as

© NUEXCO 1986

most buyers are not interested enough to rise to sellers' offers. Although supply of secondary market conversion services has declined slightly, one transaction was concluded at a level below last month's Conversion Value of $1.90.

* * *

ENRICHED URANIUM AND SWUs

The **SWU Value** as of November 30, 1986, is $80 per SWU, up $2 since last month. This refers to SWU at a tails assay of 0.30 weight-percent U$_{235}$ and for delivery within one year. Three secondary market SWU transactions are reported this month, involving approximately 200 thousand SWU.

The three reported SWU transactions generally represent the range of opportunities available on the secondary market. Small quantities of DOE-origin virgin SWUs are still available at prices between $85-100. SWUs contained in enriched product generally are available in larger quantities, at prices near the current SWU value. The SWU market remains volatile, with variables such as delivery and notification dates, payment terms, and origin contributing to a range of SWU prices. In addition, many SWU opportunities now involve increasingly complicated displacement transactions or other mechanisms that can increase cost.

November 30, 1986	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**\$16.75**/lb. U_3O_8	4,530	770
UF_6 VALUE	**\$48.00**/kgU		
CONVERSION VALUE	**\$1.80**/lb. U as UF_6	1,415	650
SWU VALUE 0.3 tails assay; delivery within one year	**\$80**/SWU		
LOAN RATE	**4%**/annum	0	0

	\$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.30**	2.0	13	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1986

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**
Australia (dollar)	25.85	26.46	24.31	67.20	68.79	63.20
Belgium (comm. franc)	694.16	724.95	861.18	1,805	1,885	2,239
Canada (dollar)	23.22	23.61	23.08	60.36	61.38	60.01
EEC (ecu)	16.16	16.46	19.33	42.02	42.80	50.27
Finland (markka)	82.31	84.75	91.63	213.99	220.32	238.22
France (franc)	108.98	113.86	129.85	283.32	296.02	337.57
FRG (mark)	33.27	34.85	42.62	86.50	90.60	110.80
Italy (lira)	23,116	24,107	28,741	60,097	62,672	74,719
Japan (yen)	2,715	2,742	3,368	7,059	7,128	8,755
Netherlands (guilder)	37.86	39.43	47.82	98.43	102.52	124.31
South Africa (rand)	37.64	38.64	44.14	97.86	100.45	114.75
Spain (peseta)	2,254	2,334	2,625	5,859	6,068	6,825
Sweden (krona)	115.68	119.13	128.55	300.73	309.71	334.20
Switzerland (franc)	27.69	28.90	35.06	71.98	75.14	91.14
UK (pound)	11.75	12.12	11.41	30.55	31.51	29.66
US (dollar)	16.75	17.00	16.75	43.55	44.20	43.55

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**
Australia (dollar)	26.70	26.85	22.93	69.41	69.80	59.62
Belgium (comm. franc)	716.95	735.61	812.34	1,864	1,912	2,112
Canada (dollar)	23.98	23.96	21.77	62.34	62.28	56.60
EEC (ecu)	16.69	16.75	18.24	43.40	43.56	47.42
Finland (markka)	85.01	85.99	86.43	221.01	223.56	224.71
France (franc)	112.56	115.54	122.48	292.62	300.38	318.42
FRG (mark)	34.37	35.36	40.20	89.34	91.94	104.52
Italy (lira)	23,875	24,461	27,110	62,070	63,594	70,481
Japan (yen)	2,804	2,782	3,177	7,291	7,233	8,258
Netherlands (guilder)	39.10	40.01	45.10	101.66	104.03	117.26
South Africa (rand)	38.88	39.20	41.63	101.07	101.92	108.24
Spain (peseta)	2,328	2,369	2,476	6,052	6,158	6,438
Sweden (krona)	119.48	120.88	121.26	310.61	311.72	315.25
Switzerland (franc)	28.60	29.33	33.07	74.34	76.24	85.97
UK (pound)	12.14	12.30	10.76	31.55	31.97	27.98
US (dollar)	17.30	17.25	15.80	44.98	44.85	41.08

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Nov. 26, 1986.

© NUEXCO 1986

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF$_6$			per kg. U as UF$_6$		
Country (currency)	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**	**This Month (Nov 30, 1986)**	**Last Month (Oct 31, 1986)**	**12 Months Ago (Nov 30, 1985)**
Australia (dollar)	2.78	2.96	2.32	6.12	6.52	5.12
Belgium (comm. franc)	74.60	81.02	82.26	164.46	178.63	181.36
Canada (dollar)	2.49	2.64	2.20	5.50	5.82	4.86
EEC (ecu)	1.74	1.84	1.85	3.83	4.78	4.80
Finland (markka)	8.85	9.47	8.75	19.50	20.88	19.30
France (franc)	11.71	12.73	12.40	25.82	28.06	27.34
FRG (mark)	3.58	3.90	4.07	7.88	8.59	8.98
Italy (lira)	2,484	2,694	2,745	5,477	5,940	6,052
Japan (yen)	291.78	306.45	321.67	643.27	675.61	709.17
Netherlands (guilder)	4.07	4.41	4.57	8.97	9.72	10.07
South Africa (rand)	4.04	4.32	4.22	8.92	9.52	9.29
Spain (peseta)	242.20	260.88	250.78	533.95	575.14	552.88
Sweden (krona)	12.43	13.31	12.28	27.41	29.35	27.07
Switzerland (franc)	2.98	3.23	3.35	6.56	7.12	7.38
UK (pound)	1.26	1.35	1.09	2.78	2.99	2.40
US (dollar)	1.80	1.90	1.60	3.97	4.19	3.53

SWU VALUE AND UF$_6$ VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Nov 30, 1986)**	**UF$_6$ Value per kg.U in UF$_6$ This Month (Nov 30, 1986)**	**UF$_6$ Value per kg.U in UF$_6$ Last Month (Oct 31, 1986)**
Australia (dollar)	123.46	74.07	74.71
Belgium (comm. franc)	3,315	1,989	2,047
Canada (dollar)	110.88	66.53	66.66
EEC (ecu)	77.19	46.32	46.48
Finland (markka)	393.12	235.87	239.28
France (franc)	520.49	312.30	321.50
FRG (mark)	158.92	95.35	98.40
Italy (lira)	110,406	66,243	68,066
Japan (yen)	12,968	7,781	7,742
Netherlands (guilder)	180.83	108.50	111.34
South Africa (rand)	179.78	107.87	109.09
Spain (peseta)	10,764	6,459	6,591
Sweden (krona)	552.49	331.49	336.37
Switzerland (franc)	132.23	79.34	81.60
UK (pound)	56.12	33.67	34.22
US (dollar)	80.00	48.00	48.00

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Nov. 26, 1986.

© NUEXCO 1986

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3876	1987	101-300	100	Producer	Trader	UF_6.
3874	1987	101-300	100	Producer	Utility	
3865	1987	101-300	less than 103	R[5]	Trader	UF_6.
3864	1986	less than 50	102	Trader	Trader	UF_6.
3863	1989-1998	5,001-10,000	R[5]	Producer	Utility	
3862	1986	101-300	105	Producer	Utility	UF_6.

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
3875	1987	300-600	94-100	Trader	Utility	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
3879	1986	less than 50	106	Trader	Utility	DOE	
3878	1987	50-100	104	Trader	R[5]	DOE	
3877	1987	101-300	94-98	R[5]	Utility	Eurodif	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.

[3] Price is not normalized to 0.20% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1986

URANIUM SUPPLY
(November 30, 1986)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2335	400	—	
2740	100	—	
2764	260	—	UF_6
2777	500	—	
2880*	125	—	
2885B*	230	—	UF_6
2893A*	480	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2975*	250	—	
2989	40	—	
2990*	130	—	UF_6
3023	500	500	UF_6
3121	500	—	
3129	500	500	
2263	—	400 per year	1988 on
2625	—	500 per year	1988 on
2781	—	250 per year	1988-95
2927	—	220 per year	1988-90
2981	—	600 per year	1988-91
TOTAL:	4,530		
INACTIVE			
2297	200	200 per year	1988-89
2336	250	250 per year	1988-94
2389	75	75 per year	1988-90
3128*	100	—	
TOTAL:	625		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: none.

© NUEXCO 1986

CURRENT MARKET DATA

URANIUM DEMAND
(November 30, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2956	350	350	U_3O_8 or UF_6
2977*	105	—	UF_6
2984*	145	—	UF_6
2991*	105	—	UF_6
3075*	65	—	
2738	—	1,000	1989 on
2962	—	500	1989 on
2985*	—	675 per year	1992 on
3019	—	200 per year	1988-91
3097*	—	300 per year	1988 on
TOTAL:	770		
INACTIVE			
2760	750	750 per year	1988-90
2798	70	—	
2948*	100	—	UF_6
2936	—	400 per year	1988-95
TOTAL:	920		

---

*New or revised since last month

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2681, 2739, 2893B, 2954.

© NUEXCO 1986

LOAN SUPPLY AND DEMAND
(November 30, 1986)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Within 1 Year**	**Beyond 1 Year**	**Remarks**
Available for Loan:			
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2667	800	—	
2920	2,000	—	
TOTAL:	5,300		

---

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: None.

No inquiries to borrow are reported this month.

CONVERSION SUPPLY AND DEMAND
(November 30, 1986)

	Delivery Period[1] (Thousands of Pounds U as UF_6)		
Nuexco Project Number	**Within 3 Years**	**Beyond 3 Years**	**Remarks**
Available for Sale:			
ACTIVE			
2859	750	750	
2935	500	—	
2988	165	—	
TOTAL:	1,415		
Inquiries to Purchase:			
ACTIVE			
2833	400	—	
2949	250	—	
TOTAL:	650		

---

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 2849.

© NUEXCO 1986

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(November 30, 1986)

	Delivery Period[1] (Thousands of SWUs)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale: ACTIVE			
2571	—	55	1987
2855	250	—	
3156*	70	—	1987
TOTAL:	320		
Inquiries to Purchase: ACTIVE			
2987*	100	—	1987-88
3015*	40	—	
TOTAL:	140		
Inquiries to Purchase: INACTIVE			
2878	60	—	
2879	250	—	
2999*	150	—	
TOTAL:	460		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2854, 2957, 2968.

© NUEXCO 1986

AUSTRALIA'S SUPPLY POSITION

Introduction

Events both within and outside of Australia are moving that country back into the forefront of uranium supply nations. During the mid and late 1970s, Australia's uranium was viewed as essential to help supply the requirements of then-anticipated future reactor programs. However, beginning around 1980, the combination of massive reactor cancellations worldwide and Australia's vacillating uranium policy resulted in many end-users perceiving Australia as an interesting *alternative* source of uranium supply rather than as a primary source. However, a number of recent developments indicate that a further shift is evident, and Australia may again be emerging as a key supplier nation.

1. An aggressive marketing campaign initiated by Energy Resources of Australia (ERA) in the USA has resulted in at least nine long-term contracts.
2. A pragmatic decision by the Australian government to end its embargo against France has allowed Queensland Mines Ltd. (QML) to resume uranium deliveries to Electricite de France.
3. Joint venture partners Western Mining and BP Australia decided to proceed with the Olympic Dam project, and recently won government approval of a sales agreement with the Swedish State Power Board.
4. Increasing political problems associated with uranium supply from South Africa and Namibia have resulted in pressures for new sources of supply.
5. A general belief exists among buyers that competitive situations should be enhanced, both between supplier nations and within those nations. Thus, as Southern Africa's role in world supply diminishes, Australia's importance in counterbalancing Canada has increased, as has Olympic Dam's importance in counterbalancing ERA.

Australian Producers —

Energy Resources of Australia (ERA)

ERA continues to produce uranium from its Ranger mine and mill at Jabiru at the rate of about 6.6 million pounds U_3O_8 annually, and has announced plans to double that capacity in two stages by the early 1990s. About 75 percent of current production is committed to shareholder customers in Japan, the Federal Republic of Germany and Sweden, and the balance is sold to Korean, Belgian and US utilities. Of particular interest are the US contracts, which now reportedly total nine and include American Electric Power, Florida Power & Light, Pennsylvania Power & Light, Philadelphia Electric, Portland General Electric, South Carolina Electric & Gas, Southern California Edison, Virginia Electric Power, and Wisconsin Electric Power.

While individual contract details are not available, aggregate deliveries under these contracts could total 2.5 million pounds U_3O_8 annually by the late 1980s or early 1990s. However, those contracts contain considerable flexibility, and the quantities actually delivered will be a function of contract price. In view of Australia's established floor price policy and the reluctance of US buyers to pay in excess of spot-market prices, it is apparent that these contracts with US buyers must contain not only incentives but also comprehensive price protection. Incentives include flexibility with respect to the quantity and timing of deliveries, as well as delivery price provisions that call for substantial discounts from the spot price whenever it exceeds the floor price.

To avoid being locked into long-term obligations to take and pay for uranium at prices in excess of the spot-market price, there are price or quantity related triggers that provide for the reduction, suspension, or termination of deliveries. The contracts also contain so-called debit/credit arrangements, under which amounts paid in excess of spot-market price are utilized to reduce future delivery prices that exceed the floor price. Some contracts have provisions that excuse the buyer from purchasing if the uranium cannot be utilized due to US import restrictions, unless the seller elects (or is required) to provide acceptable uranium through open-market purchases.

Under the ERA strategy, risks to both buyer and seller appear to be minimal, and the benefits could be substantial. Most importantly, ERA has been able to penetrate the US market, and every ERA customer is one less potential customer for Olympic Dam; few if any US utilities will buy significant quantities from more than one Australian supplier. Finally, US utilities risk little to become associated with a producer capable of providing supply for the life of the reactor.

If near-term uranium prices reach or exceed the Australian floor price, ERA will produce and deliver the uranium, assuring its market position. Subsequently, its next expansion of production capacity (to 9.9 million pounds U_3O_8 annually) would be base loaded. This would also be the case if the government alters or removes the floor price, even if prices do *not* rise. In the last scenario, if prices do not rise and the current floor price remains in effect, US buyers will likely reduce deliveries or opt out of the contracts with minimum financial exposure, and buy from other, more competitive sources. Presumably, ERA would be no worse off than if it had never entered into the contracts with US buyers.

The situation with ERA's other customers, particularly its shareholders, is more complex. From the onset of their deliveries, those customers have been contractually bound to take large tonnages at prices which were not only considerably higher than spot market levels but also higher than prices prevailing

© NUEXCO 1986

under long-term contracts covered by negotiated pricing terms. Notwithstanding the profits those other customers have earned as equity investors, their general unhappiness with the current arrangement is well known and there have been reports of negotiations toward a resolution of these difficulties.

Olympic Dam

The Olympic Dam (Roxby Downs) project was examined in detail in Report 218 (October 1986). Since then, the joint venture partners Western Mining and BP Australia have announced that the anticipated contract with the Swedish State Power Board has been approved by the Australian government. The transaction involves about 550,000 pounds U_3O_8 annually for the years 1989 to 1999. A contract with the United Kingdom's Central Electricity Generating Board is also reportedly close to completion.

Olympic Dam's marketing challenge is significant. Its primary Australian competitor, ERA, has been in production for some years and has established itself as a reliable supplier. Without a reversal of government policy, price competition is not a realistic strategy. Olympic Dam's thrust has been to present itself as a viable alternative to ERA, emphasizing flexibility and customer service. Assuming some buyers will prefer to have sellers in competition with one another, it appears that Olympic Dam should achieve a significant market share.

Queensland Mines

Queensland Mines is in a unique position, as it is the smallest of the current Australian producers and is the lowest-cost producer in Australia, if not the world. Its uranium is completely stockpiled, leaving only a milling operation at Nabarlek. Thus, QML possesses the lowest risk and highest security of supply. Current supply contracts exist with two Japanese utilities, one Finnish utility, and Electricite de France.

Lacking agreement with the Northern Land Council to explore for new deposits in the Northern Territory, QML is not in position to offer long-term supply, and accordingly finds itself at a considerable marketing disadvantage to ERA and Olympic Dam. With little uncommitted supply at present, QML is essentially a spot seller in a country where the government-mandated minimum price is nearly twice the current spot level. QML has stated that it is committed to the uranium business and continues to work towards obtaining authorization to resume its exploration activities in promising areas of Arnhem Land.

Politics and Policy

For many years, the uranium issue has been an integral part of the political situation in Australia and a contentious issue between political parties, within the Labor party itself, between Australian states, or even between the individual uranium companies. In general, the following observations can be made.

1. The Liberal and National Country parties have consistently adopted pro-uranium platforms.

2. The Labor party had been consistently anti-uranium when out of power. Since attaining power, economic reality has caused the Labor party leadership to adopt a policy of grudging acceptance. Nevertheless, a vocal left wing of the party remains categorically opposed.

3. Opposition to uranium mining is centered in the two most populous states, New South Wales and Victoria, which are also the main centers of union activity.

4. Official federal and state government policies and attitudes on uranium change when the party in power changes.

5. For a variety of reasons unique to Australia, uranium mining and export continue to be emotional issues with the Australian public.

6. The former government's policy of sequential development, and the current Labor government's current policy of limited development, have frequently set the various mining companies in opposition to one another as they maneuver for position.

Conclusion

Government and commercial rhetoric aside, Australia's hopes for gaining and maintaining credibility as a reliable, world-class supplier in the long term are dependent on two related factors. First, there must be confidence among buyers that successive Australian governments will not continue to change the policies concerning Australia's uranium supply. The current Labor government has taken steps in this direction by allowing Olympic Dam to proceed and by allowing the resumption of QML's deliveries to EdF.

Second, the government must adopt a realistic view of its ability to dictate commercial conditions. In the late 1970s, Australia squandered its opportunity to join the front rank of supplier nations. Today, the floor price is perhaps the primary example of a policy that directly contradicts economic reality. In the longer term, Australia will not be able to command prices substantially above those offered by other sellers. Much of Australia's marketing success was achieved in a different market environment or is a reflection of buyers seeking to balance geopolitically their sources of supply. Premium prices that were justifiable to initiate a project are not likely to remain justifiable in the long term.

The history of the floor price demonstrates that while even the most intransigent entities can change, that change is typically so slow that the opportunity motivating the change is lost. Initially, the floor price was established as US\$30.00 per pound U_3O_8, at least 55 percent of which was subject to adjustment by certain Australian indices from January 1, 1980. That floor was escalating as spot prices were falling, and by September 1980, the spot price was below US$30.00 and still declining. At that point, Australian sellers (presumably with government sanction) spoke of freezing the floor price at its then-current level until spot prices once again were higher than the floor price, at which time the floor would again be escalated.

As spot prices moved still lower, debit/credit arrangements began to appear in contracts, as did the first provisions for the reduction or suspension of deliveries if certain conditions appeared. With the continued weakness in spot prices during 1984, 1985 and 1986, it became apparent that the Olympic Dam partners could have problems launching the project if the existing floor price policy was not changed. Though not officially announced, it is clear that the government will approve sales contracts with more flexible pricing provisions. The current goal appears to be that the average price over the life of the contract should at least equal the floor price. More recently, there have been rumors to the effect that even lower prices might be acceptable in special circumstances, such as in short-term contracts where the contract duration would presumably be too short for the expected future price increase to bring the average price up to $31.00.

If so, the government may soon be forced to accept prices for *current* deliveries that are below the established floor. Much of that pressure will likely come from ERA's shareholder customers. Under the terms of their original contracts, those shareholders have the option to terminate deliveries after 1990 if, after 1984, they are obliged to pay the floor price for two years in a row. It would be surprising if Australia, having gained a significant market position and with the prospect of improving that position, failed to acknowledge and accept this commercial reality.

© NUEXCO 1986

GERMANY'S THTR 300 AND THE HIGH-TEMPERATURE REACTOR PROGRAM

Introduction

The Thorium High-Temperature Reactor (THTR 300) in the Federal Republic of Germany reached its rated power of 300 MWe for the first time in late September 1986. The unit reached commercial operation in April 1986. This event marked an important step in high-temperature reactor (HTR) development worldwide. The FRG embarked on the research and development of this generation of nuclear power reactor design over 25 years ago. Other countries' experience with gas-cooled reactors, most notably in the United Kingdom, was used in the development and construction of HTR plants in the FRG. The gas-cooled THTR 300 prototype plant, designed and built by consortia of manufacturing, construction, and nuclear fuel cycle companies, represents the second phase of the German HTR strategy. The companies involved in the commercialization of the HTR hope to apply the reactor line to electricity generation, process heat production, and they anticipate that HTR development will result in increased flexibility in the nuclear fuel cycle.

History of the HTR Program

Nuclear power research and development efforts in the FRG in the 1960s led to experimentation with reactor systems and designs other than the conventional light-water reactor. Among the most promising technologies are the fast-breeder reactor, under development in several nations, and the gas-cooled reactor. Of the latter, the Magnox line and the second-generation Advanced Gas-cooled Reactor (AGR) have been the foundation of nuclear power in the United Kingdom for decades. General Atomic (now GA Technologies Corporation) pioneered the high-temperature gas-cooled reactor in the USA, notably Public Service Company of Colorado's Fort St. Vrain plant. In the FRG, the high-temperature gas-cooled reactor was developed in the 1960s by Brown Boveri/Krupp Reaktorbau GmbH, now known as Hochtemperatur-Reaktorbau GmbH (HRB).

HRB built the first experimental high-temperature reactor, designated AVR-15, a 15-MWe unit located near Jülich. The unit, which began operation in 1967, utilizes a loose bed of spherical fuel elements which form the reactor core. During operation, the fuel elements are continuously added from above the core and discharged from below it, making plant shutdown for refueling unnecessary. The pebble bed core of the AVR-15 is cooled by a flow of helium gas, which is heated to between 700 and 950°C., depending upon the application. The heated gas flows through heat exchangers and is then recirculated through the core for reheating.

Shortly after operation of the experimental unit began, HRB and the research facility at Jülich, with financial support from Euratom and the federal government of the FRG, developed the design and plans for a 300-MWe Thorium High-Temperature Reactor (THTR). Interest on the part of a group of German electric utilities led to the formation of Hochtemperatur-Kernkraftwerk Gesellschaft mbH (HKG). Table 1 lists the participants and their respective ownership shares in HKG. HKG and Vereinigte Elektrizitaetswerke Westfalen AG (VEW) own the THTR project, and HKG oversees the construction and financing of it. HKG selected the site for the THTR in VEW's utility area, near the towns Hamm and Uentrop in North-Rhine Westphalia. In 1970, HKG placed the order for the plant's construction with a consortium composed of Brown, Boveri & Cie. AG, HRB, and Nukem GmbH.

Table 1

OWNERSHIP OF HKG[1]

Owner	Location (City)	Percent Share
VEW[2]	Dortmund	26
GKW[3]	Veltheim	26
Elektromark[4]	Hagen	26
GWH[5]	Hattingen	12
Stadtwerke Aachen AG	Aachen	5
Stadtwerke Bremen AG	Bremen	5
		100

[1] HKG = Hochtemperatur-Kernkraftwerk GmbH.
[2] VEW = Vereinigte Elektrizitaetswerke Westfalen AG.
[3] GKW = Gemeinschaftskraftwerk Weser GmbH.
[4] Elektromark, Kommunales Elektrizitaetswerk Mark AG.
[5] GWH = Gemeinschaftskraftwerk Hattingen GmbH.

Description of the THTR

Figure 1 shows a basic diagram of the plant. The THTR consists of a two-cycle system. In the primary circuit, heat generated in the core is transferred by the flow of helium gas primary coolant to the steam generator. The secondary circuit absorbs the heat to produce steam, which drives the turbine generators and is recycled. As in a pressurized water reactor, there is a distinct separation between the radioactive primary circuit and the non-radioactive secondary loop.

© NUEXCO 1986

The core consists of a statistically arranged bed of 675,000 spherical elements (Figure 2). Of those, about 358,000 are uranium-thorium fuel elements, about 44,000 are absorber elements, and about 273,000 are graphite moderator elements. The absorber and moderator spheres present in the initial core are gradually replaced by fuel elements in the first four years of operation. Each element is about the size of a tennis ball, and fuel elements contain 192 grams of carbon, 0.96 g uranium 235 (from 93-percent enriched uranium), and 10.2 g thorium 232. During neutron absorption, the thorium is converted into fissile U_{233}.

Each fuel sphere consists of a 5-mm-thick graphite shell surrounding a graphite matrix which contains coated fuel particles. The particles are UO_2 and ThO_2 kernels coated with three pyrocarbon layers, which serve to retain the fission products. This type of fuel element has two important advantages:

1. High mechanical strength due to the structural properties of the graphite shell and inner matrix;
2. The retention of fission products, so that little radioactive contamination is released to the circulating helium gas.

Figure 3 shows a cutaway view of the fuel spheres.

During operation, six coolant blowers force the helium coolant gas to flow downward through the reactor core. The fission heat raises the temperature of the helium to 770°C., and the gas is collected beneath the reactor core. From there it is directed to the steam generators. The helium gas transfers heat to water in the steam generators, where the helium is cooled to about 260°C., and is redirected to the core by the coolant blowers. Steam produced in the steam generators drives the turbine, is condensed in the condenser, and is pumped back to the steam generators.

The THTR employs a fuel circulating facility that permits the continuous loading and discharging of the spherical fuel, moderator, and absorber elements during operation of the plant. As in the AVR-15 experimental plant, the spheres are added from the top of the core and discharged from the bottom. The reactor core is divided into two refuelling zones, and each fuel element spends an average of six months in one passage through the core during full operation. After each passage through the core, each fuel element is tested in a burnup measurement vessel, and those that have not reached a specified degree of burnup are recirculated into certain areas of the core for further use. The placement of the used fuel spheres depends upon the distribution of power density.

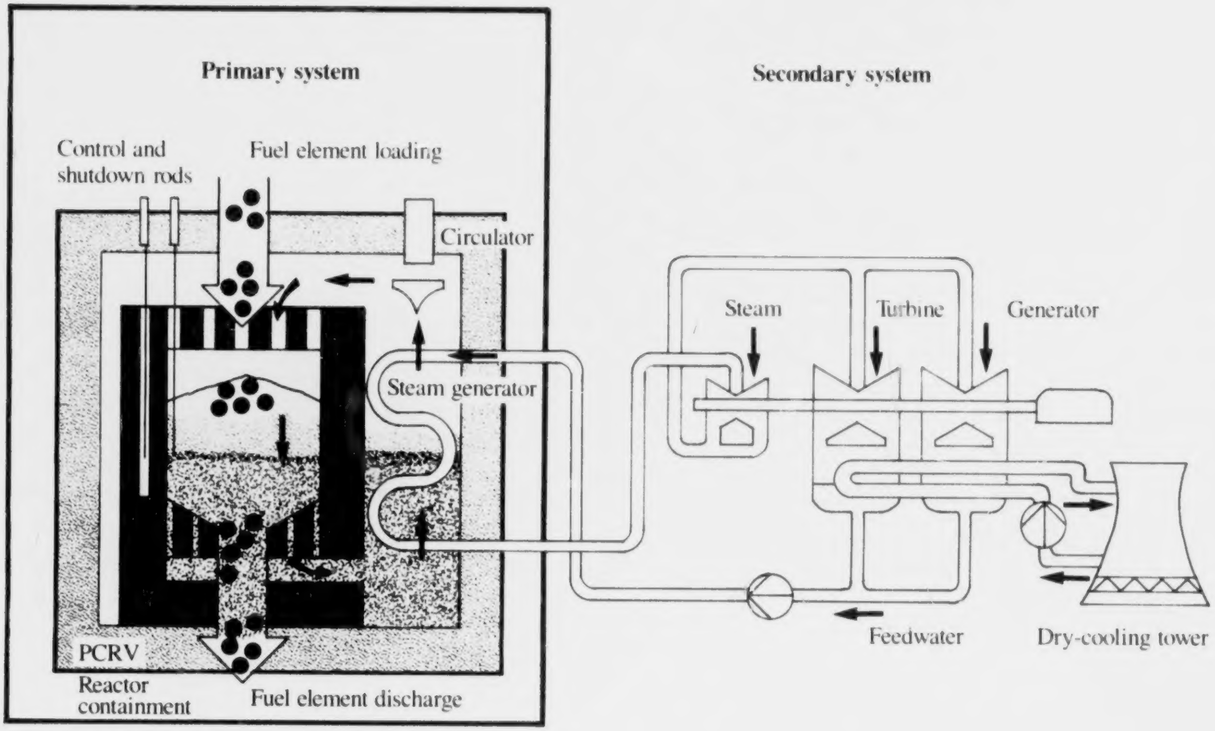


Figure 1. Basic diagram of the THTR-300.

© NUEXCO 1986

BASIC CONSIDERATIONS

Several features of the THTR were designed with particular attention to safety concerns.

1. The reactor core has a negative temperature coefficient, so that an increase in core temperature results in a decrease in reactivity. Neutron absorption by the thorium absorber in the fuel elements rises as temperature increases, reducing the core's reactivity.

2. The unit has a low ratio of power density to heat capacity, so that failures affecting heat production or removal (such as a loss of coolant accident) do not result in rapid temperature changes in the core.

3. The ceramic fuel elements have high temperature resistance and a high structural stability.

4. The core is equipped with two shutdown systems — a set of 36 absorber rods containing the absorber boron carbide (B_4C) inserted into the side reflector surrounding the pebble bed, and 42 in-core rods inserted directly into the bed. The side reflector rods are used to control pressure and temperature in the core, and the in-core rods are used for long-term shutdown. Both sets of rods would be inserted under accident conditions.

5. Helium's properties are ideal for a core coolant, because it is chemically inert and has no influence on reactivity. In addition, because it is a gas, a total loss of coolant cannot occur; at least one atmosphere of helium will remain inside the reactor vessel to provide decay heat removal.

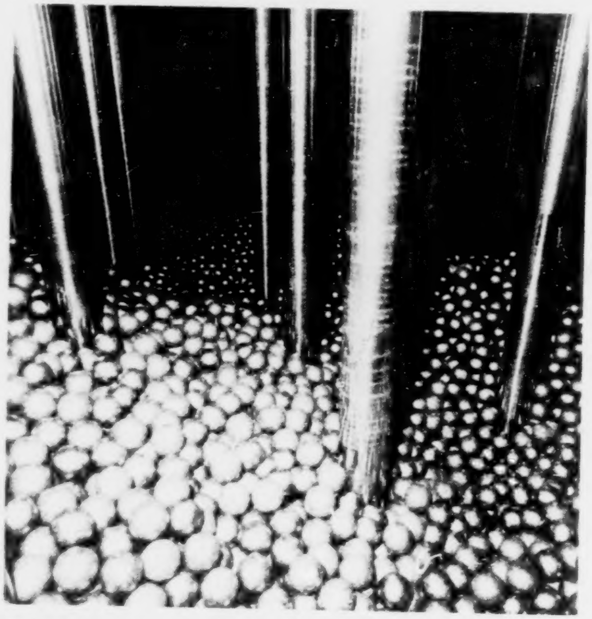


Figure 2. View of the reactor core, showing spherical fuel elements and in-core control rods.

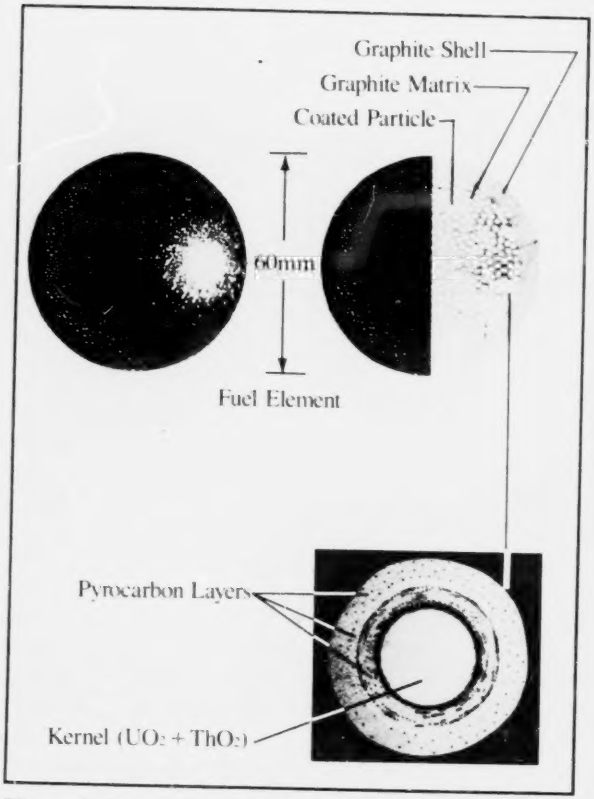


Figure 3. Structure of the THTR Fuel Element.

Commissioning of the THTR 300

Fuel elements were loaded in the THTR in August 1983. To avoid dropping the spheres from the full height of the core while it was empty, a special loading device was used. In October 1983, the core was fully loaded, and technicians withdrew the in-core absorber rods to achieve criticality so as to determine the effectiveness of the core design. Ten months later, a hot performance test was conducted utilizing nitrogen, which is a neutron absorber, in place of the helium coolant. Further testing during 1984 focused on reactivity measurements using nitrogen and helium, tests of the fuel circulating system, and control rod insertion tests. In April 1985, following the issuance of a second partial operating license, hot performance and safety systems tests began, using the helium gas coolant atmosphere at nearly operating pressures. Low-power nuclear operation began on September 6, 1985, and the unit was supplying electricity to the VEW grid shortly thereafter. HKG assumed ownership of the unit on April 11, 1986.

© NUEXCO 1986

Although the unit is in commercial operation, a condition of the operating license allows operation only until the core reaches its equilibrium burnup condition, which is expected to occur in three to four years. This condition is a result of political complications in the FRG over spent fuel storage sites. HKG has permission to store some spent fuel on the THTR site. However, court orders following regulatory disputes have closed the interim spent fuel storage site at Gorleben and have halted construction of a waste repository at Ahaus. As a result, HKG may encounter licensing problems if a longer-term spent fuel management solution is not found. Currently, reprocessing is not available for the THTR fuel spheres.

Future of HTR Program

The success of the THTR has already led to further development of the high-temperature reactor program in the FRG. Detailed design of a 550-MWe-plant, designated HTR-500, is underway, using technology and experience gained from operation of AVR-15 and THTR-300. Although the HTR program has been primarily promoted by the Ministry of Research and Technology branch of the federal government and the state of North-Rhine Westfalia, many utilities and nuclear fuel cycle companies are now initiating HTR research and development. The multiple potential applications of HTRs — for electricity generation as well as process heat utilization such as coal liquefaction and gasification — make the HTR an attractive design for future generations of nuclear power. Other areas of application include cogeneration of electricity and district heating, the production of synthetic gas from coal and other hydrocarbons, the production of methane or hydrogen from coal, and other potential uses. Some of these possible applications are part of an overall development plan by BBC/HRB, shown in Figure 4. The THTR will be the reference plant for the consortium's subsequent generations of high-temperature reactors.

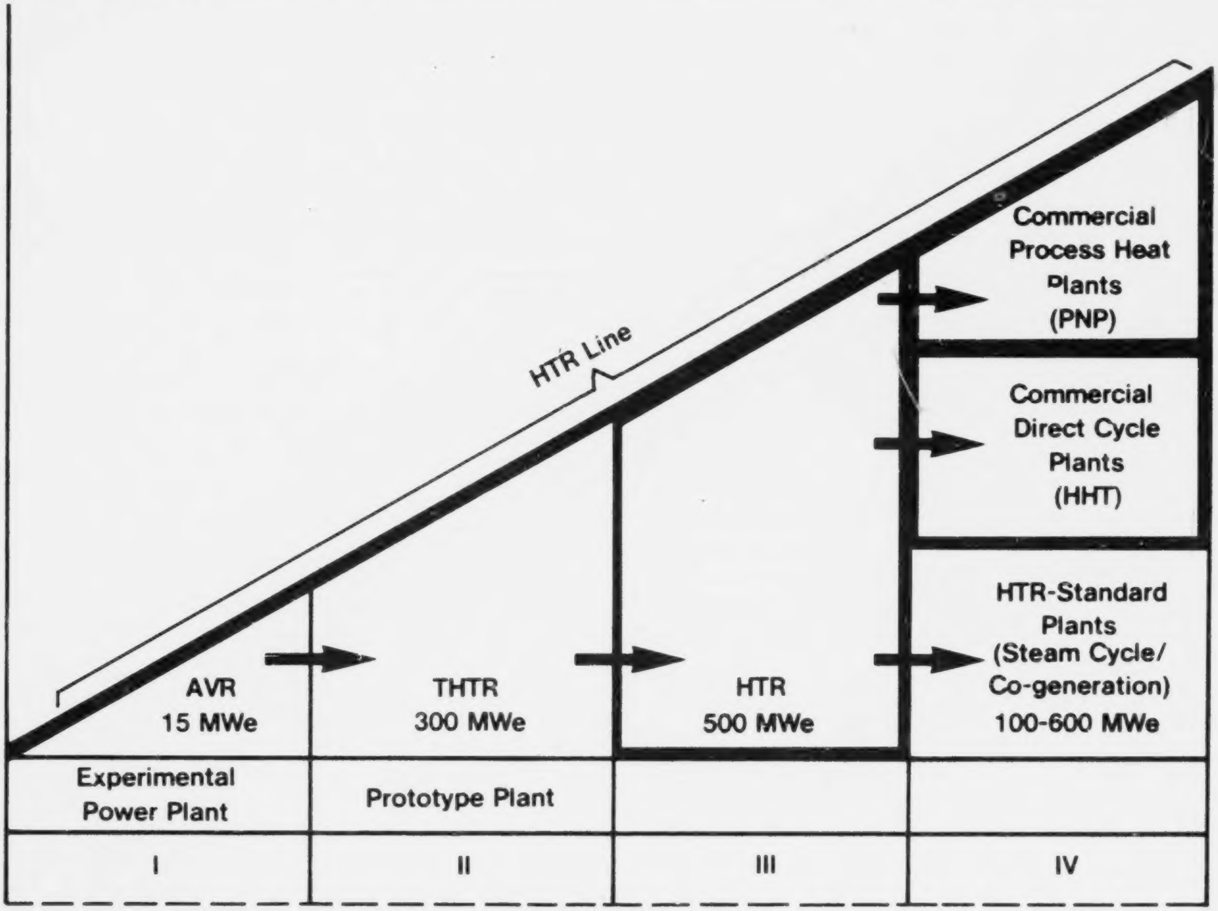


Figure 4. Sequence of Technical Development of the High-Temperature Reactor.

© NUEXCO 1986

UNITED STATES

The US Energy Information Administration (EIA) has released its annual report entitled "Domestic Uranium Mining and Milling Industry: 1985 Viability Assessment." The EIA is an independent statistical and analytical agency within the US Department of Energy. A 1983 amendment to the Atomic Energy Act of 1954 requires the Secretary of Energy to make an annual determination of the industry's viability, and the EIA study is intended to provide the Secretary with the information needed to make such a determination. The 1985 assessment indicates that the condition of the US uranium industry is worse in most areas than it was in 1984, making a determination of nonviability almost a certainty. The Secretary of Energy has not yet issued his determination for 1985.

In his first annual determination for the calendar year 1983, the Secretary of Energy found that the domestic uranium mining and milling industry was viable, while noting concern with the long-term health of the industry. The following year, the Secretary determined that in 1984, the industry was not viable. As criticism of his findings increased, the Secretary announced that he would undertake three steps designed to bolster the domestic industry.

1. Herrington authorized DOE to offer a free variable tails assay option (VTAO) each year to all customers that commit to buy 100 percent of their requirements from DOE over a rolling five-year period.

2. He postponed for one year a DOE plan to feed some of its own uranium stockpile into enrichment plants. This item also was sought in Count IV of the US uranium producers' lawsuit against DOE. DOE subsequently told the Tenth District Court that it would not implement the plan at all.

3. He asked the US Trade Representative to examine the facts and implications of uranium imports and corresponding foreign trade and policy issues with a view toward determining the appropriate courses of action under US trade laws. Three months later, Trade Representative Clayton Yeutter recommended that no action be taken, citing the conclusions that any relief to the US industry from a standpoint of restricting imports would be at best only short-term relief, and would likely antagonize US trading partners.

Viability Assessment Criteria

Pursuant to a rulemaking in October 1983, the Secretary of Energy is required to monitor and make an annual determination of the viability of the US uranium industry. The rulemaking delineated several criteria that are to be considered in making the viability determination; the EIA study provides data and information that are fundamental measures of the industry's capability. Moreover, the study provides estimates of future capabilities under a variety of hypothetical conditions.

The criteria define four major "attributes of viability:"

1. *Resource Capability* — Whether domestic economic uranium reserves can supply all domestic needs for a future ten-year period.
2. *Supply Response Capability* — The level of domestic uranium production capacity sufficient to meet projected domestic nuclear power needs for a ten-year period.
3. *Financial Capability* — The ability of the domestic uranium industry to obtain funds adequate to finance the level of production capability defined under supply response capability.
4. *Import Commitment Dependency* — Whether executed contracts or options for (natural or enriched uranium) will result in greater than 37.5 percent of actual or projected domestic uranium requirements being supplied by (uranium) from foreign sources for any period of two consecutive years.

The EIA assessment provides current information and makes projections of future conditions of each of the four fundamental attributes as well as some related ones, such as a projection of industry status under both supply disruptions and free market conditions. Some of the most pertinent and interesting data and conclusions are summarized below.

Current Status of the Industry

The report concludes that almost all of the short-term indicators of the domestic uranium industry's health are weak, and many are weaker than in the previous assessment; that assessment resulted in the Secretary's finding that the industry was not viable for 1984. Some of the more important indicators are the following.

1. US uranium production in 1985, which totaled 11.3 million pounds U_3O_8, declined to its lowest level since 1956. The 1985 figure represented a 24-percent decline from 1984 production of 14.9 million pounds U_3O_8.

2. After realizing positive net income in the years 1981-1983, the US industry lost a total of $307 million in 1984. Total losses increased to $350 million in 1985.

3. The number of firms investing in domestic uranium exploration, mining and milling, as well as their associated capital investments, have reached their lowest levels since the government began collecting such statistics in 1973. Exploration expenditures fell from $27.4 million in 1984 to $20.1 million in 1985. Drilling activity, the primary indicator of exploration effort, fell from 2.5 million feet in 1984 to 1.8 million feet in 1985.

4. The production costs of the vast majority of US uranium

producers are well above recent contract prices.

The 1985 status of import commitment dependency showed that the US utilities as a group relied a little less on imported uranium for their requirements than in previous years. Natural uranium imports represented 52 percent of US requirements in 1982, 25 percent in 1983, 39 percent in 1984, and 34 percent in 1985. However, this indicator will fluctuate widely from year to year depending on contract volume, and it is difficult to discern any real trends from these figures. It might be more valuable to examine these figures in relation to the volume of uranium purchased by US utilities. Moreover, the study concludes that foreign-origin uranium is "likely to fill a growing portion of currently unfilled utility requirements and long-term utility purchase commitments with domestic suppliers during the second half of this decade." In the 1990s, import dependency could range from 45 percent to as high as 60 percent of domestic utility requirements, according to the EIA report.

Import commitment dependency that results in imports totaling more than 37.5 percent of US requirements for two consecutive years is one of the criteria used to assess viability. However, that dependency indicator's fall to 34 percent in 1985 is not, in itself, sufficient for a finding of industry viability. Other factors and indicators, many of which declined further from last year's marks, will negate the effect of the small decline in import dependency.

Disruption Scenarios and Supply Response Capability

Hypothetical supply disruption scenarios are used to estimate the US industry's ability to respond over the next ten years to a one-third disruption of uranium import contracts now in place. In other words, if only two-thirds of the non-US uranium supply currently under contract were actually delivered, would the US production sector be able to fill any void left by the decline in imports of non-US uranium? To arrive at the estimates, the study examines the US industry's resource capability, financial capability, and ability to meet the supply security requirements of US utilities. The EIA study concluded the following:

1. Even with a one-third disruption of foreign supplies, domestic uranium suppliers report that US resources are sufficient to meet domestic uranium supply security requirements through 1996.

2. DOE estimates of reasonably assured resources in the USA support the above conclusion.

3. In the short term, the US uranium production sector would have the *technical* capability to meet domestic supply security requirements in the event of a one-third disruption. However, in the 1991-2000 period, the EIA report indicates that production capacity would fall short of requirements by five to eight million pounds U_3O_8 in the event of a hypothetical one-third import disruption.

4. For the short-term disruption scenarios, mining and milling capacity that already exists, either in operation or standby, can meet uranium requirements through reactivation and increased utilization. However, higher uranium prices would be required to increase production during a disruption period.

Conclusion

It is clear from the EIA viability assessment that it will be difficult for Energy Secretary Herrington to determine that the US uranium industry was viable during 1985. The industry's profitability, production levels, and future supply capability have all declined further. The finding of nonviability for 1984, therefore, will practically force Herrington to repeat that finding for 1985.

A second finding of nonviability will place added pressure on DOE to implement measures to bolster the US industry. But because DOE has avoided implementing any effective measures for several years, and has indicated that it intends to continue such a policy, the producers are not likely to receive any significant help from DOE even if the industry is found to be nonviable for the second consecutive year. At this stage, it appears that only a final ruling in favor of the US producers in their lawsuit against DOE will provide the industry with any real relief.

SOLUTION MINING OF URANIUM, Part I

Introduction

Solution mining technology has improved steadily over the past ten years, a period of generally poor industry economics in which operating and regulatory costs have escalated considerably. In general, solution mining represents a cost-effective and environmentally attractive means to produce uranium, especially from the low-grade reserves often found in the USA. The emphasis on uranium production in the United States continues to shift from underground and open-pit mining and conventional milling procedures to solution mining techniques.

Overview of Solution Mining

Solution mining of uranium is commonly referred to as in-situ leach mining (ISL). The solution mining process, however, requires that the target ore be confined within an aquifer, and so it is considered an extension of in-situ leaching. Often the two terms are used interchangeably, and both use the principle of hydrometallurgy to recover metals from various ores. Technically, as practiced today, solution mining is limited to uranium recovery, while the application of ISL techniques also applies to the recovery of other metals. ISL refers to the induction of a special leach solution into any suitably prepared ore deposit. The desired mineral is leached from the deposit, enriching the solution before the solution is recaptured. The final steps of the hydrometallurgical process include mineral extraction (from the pregnant solution), concentration, and precipitation. In addition to uranium, other metals such as copper, gold, silver and manganese are amenable to varied ISL applications.

The recovery of uranium by solution mining is uniquely dependent upon the ore deposit and host formation being confined within an aquifer. The aquifer water serves four important functions in the leaching/recovery process:

1. It is used to form the leach solution;
2. It serves to move the leach solution within the deposit;
3. It allows operational control of the induced solution, particularly over possible solution excursions outside the desired area of influence;
4. The natural flow of the aquifer helps restore a natural state from chemical changes that may occur in the groundwater and host formation during the leaching process.

Containment of all leach solutions is normally achievable throughout the life of the project. The use of aquifer waters in the mining process, followed by aquifer restoration, represents the technological differences between solution mining and straight ISL mining.

Solution mining is derived from the more conventional techniques for mineral recovery by induced solutions, including heap leaching, in-place leaching and percolation leaching. The technology generally has been applied to the recovery of uranium in situations where ore concentrations and geologic conditions were poorly suited to conventional mining methods. Early research and development focused on using the hydraulic and chemical characteristics of the aquifer waters in a closed circuit of leaching and recovery, which the developers of the process referred to as solution mining. Since then, the technology has improved, but the basic concept remains the same.

Geological Requirements

Many sandstone uranium deposits located in the western USA have characteristics favorable to solution mining. However, virtually all solution mining activities to date have been limited to paleochannel sand units within Tertiary formations in Texas and Wyoming. Projects in other regions have been initiated, usually in older host rocks, but none have operated successfully; reasons for this lack of success have ranged from unfavorable geochemistry to unfavorable economics and politics.

Successful solution mining depends greatly upon orebody characteristics and selection of the most effective lixiviant (the solution used in the process). The ore minerals must have been deposited in a reducing environment (i.e., they must be in an oxidized state), and the ore deposit must be of sufficient size, shape and thickness to accommodate mining procedures and produce advantageous economic results. Roll-front deposits fit the requirements well, being long and sinuous and reasonably flat-lying. Although higher-grade ores naturally offer greater economic potential, the process was developed out of a need to mine low-grade ore. Considering this, a grade of 0.10 percent U_3O_8 is about average in past operations, although some projects have operated with lower grades. Projects presently under consideration for commercial start-up are supported by higher-grade deposits as a matter of economic necessity.

Roll-front deposits common to Tertiary channels are readily amenable to solution mining. Generally, these ore deposits are associated with poorly-sorted sands and conglomerates where consolidation is incomplete, and so permeability is usually favorable. Roll-type uranium deposits occur along a chemical front which clearly exhibits an oxidation/reduction zone. When the leach solution (lixiviant) comes into contact with insoluble uranium oxides and silicates, oxidation occurs and quadravalent (+4) uranium minerals (uraninite and coffinite) are converted to the hexavalent state (+6), forming soluble uranyl carbonates. In the recovery plant, the uranium dissolved in the lixiviant is

© NUEXCO 1986

concentrated by ion exchange methods followed by precipitation.

Adequate formation permeability is extremely important to the distribution and contact rate of lixiviant through the mineral zone. Successful solution mining requires permeabilities that allow rapid movement of aquifer fluids and induced lixiviants. Most Tertiary sandstone units exhibit relative high rates of permeability; the older and deeper sandstones, such as the uranium-bearing Jurassic formations of the Grants mineral belt in New Mexico, are well-compacted and show considerably less permeability. Many geologically older ore deposits may not be suitable for solution mining primarily for that reason.

Depth of the ore-bearing strata is directly related to mineability and project economics. As mentioned above, permeability is likely to be adversely affected by depth. In addition, exploration, development, and construction costs increase rapidly at increased depths, and operating costs will be higher because of increased pumping costs. On the favorable side, oxidation induced by contact with the lixiviant is more efficient because of greater formation pressure, potentially increasing the uranium recovery rate.

Another critical condition for successful mining concerns the characteristics of the confining aquifer. Confinement of all natural and induced fluids is controlled by the presence of impermeable formations above and below the ore-bearing strata. Such layers may consist of either shale, clay and mudstone, or any combination. The impermeable layers are necessary to contain the normal aquifer flow and to aid in the manual control of the lixiviant, both horizontally and vertically. In a suitable geologic setting, the potential for fluid excursions and contamination of other aquifers is greatly reduced.

The impermeable bottom layer is definitely required for solution containment; however, the upper confining layer could be absent under near-perfect conditions of formation thickness, permeability, hydrostatic equilibrium of groundwater, and positioning of the ore zone near the base of the aquifer. In such a case, project operations must be monitored closely to check for lixiviant movement upward into barren portions of the aquifer.

Geochemistry

Host rock mineralogy and groundwater chemistry must be understood in order to develop an efficient mining process. As a result of rapid changes in the sedimentary sequence, physical properties may vary greatly between fine to very coarse-grained sands and conglomerates. Each change represents a probable variation in host rock mineralogy. The presence of clay particles, especially in finer-grained materials, tends to reduce porosity and permeability, thus restricting mining efficiency. Pyrite grains and carbonaceous fragments commonly occur throughout much of the depositional sequence associated with uranium mineralization. Each is a known oxygen consumer and the presence of one or both requires a higher injection rate of the primary oxidant used in the operation, be it hydrogen peroxide or liquid oxygen, increasing operating costs accordingly. If pyrite is present, mild sulfuric acid is generated. The acid may cause the precipitation of gypsum, which will tend to decrease formation permeability as well as adversely affect upstream process equipment. In addition, the presence of vanadium or molybdenum can foul the recovery circuits.

Usually groundwater chemistry is relatively simple. If the chloride content is less than 2.5 grams per liter, and total dissolved solids are less than 10,000 ppm, the water is usable without much adjustment other than the addition of proper amounts of leaching chemicals. Information about the quantity of available water, its direction of flow, and the hydrostatic pressure must also be determined. If an adequate quantity of groundwater is not available and another source of water must be introduced, production costs will increase and restoration costs probably will increase.

During the exploration phase of the project, subsurface conditions are evaluated leading to a preliminary understanding of orebody characteristics. The design process begins with the first mineralized holes drilled. Characteristics of the aquifer are determined during the drilling phase, and confirmed through on-site testing. Chip and core samples taken from holes strategically placed over the ore deposit are carefully evaluated for all essential characteristics, including ore amenability to leaching. Development of a suitable lixiviant is started in the laboratory and finalized by actual on-site pilot testing. Engineering design work is followed by the application of state-of-the-art process technology for the leaching and recovery facilities.

Lixiviant Formulation

The rate of uranium dissolution in the presence of the selected lixiviant is the most critical chemical process of a solution mining operation. Especially during the early years, the determination of the right lixivant was done by trial and error. Today, however, it is a more precise science, subject to variation in each application. The chemical makeup of any lixiviant is initially based on the geochemistry of the ore deposit and is confirmed in the laboratory. Chemical formulation aims to achieve maximum uranium extraction with minimum changes to host rock permeability and aquifer chemistry. Two types of lixiviants are normally used — acid and alkaline — and each has advantages and disadvantages depending on process technology, location, and economics. One of the primary considerations in lixiviant selection is the need for both surface and subsurface restoration.

Sulfuric acid combined with an oxidant is an extremely efficient leaching agent for oxidized uranium, and has been used in solution mining operations with considerable success. Unfortunately, it will dissolve a variety of other minerals that can contaminate the uranium recovery system. Its reaction with clays, calcite, and quartz grains causes precipitation of gypsum and silica gel, both of which reduce formation permeability. Sulfuric acid is no longer acceptable for solution mining in the USA, primarily due to environmental concerns. Nitric acid has also been used, but is less effective and more costly than sulfuric acid.

Alkaline-based lixiviants are now used almost exclusively throughout the industry. In the early 1970s, ammonium carbonate-bicarbonate was used extensively. Leaching results were extremely favorable, but restoration of the groundwater and the removal of ammonia cations from clay minerals proved troublesome, resulting in a ban on its use. Sodium carbonates are now the most widely used lixiviants. Sodium carbonate has the advantage of leaching primarily uranium, but at a comparatively slow rate; many other minerals or chemicals remain unaffected. A high pH is easily maintained throughout the system, almost completely eliminating the precipitation of calcite which could decrease permeability. However, sodium may cause swelling in certain clays such as montmorillonite, which definitely reduces permeability. The use of sodium carbonate (or any carbonates) also improves restoration procedures. Potassium carbonate in particular has a high leach rate and is easily recovered, allowing for rapid restoration. It has not been used on a commercial scale because it is more expensive than other carbonates, but still has the potential for increased use due to its restoration qualities.

Oxidants must be added to the lixiviant to convert the uranium to the hexavalent state (+6). Currently the most favored oxidant is liquid oxygen. Since the development of down-hole techniques to introduce oxygen gas into the lixiviant stream at the point of injection, its use had become widely accepted by the late 1970s. Oxygen quickly proved more efficient and less costly than hydrogen peroxide, which was used extensively up to that time. Sodium chlorate and air also have been used as oxidants but with considerably less efficiency.

Restoration Procedures

Solution mining projects are allowed to begin commercial production under the condition that technology is provided for the satisfactory restoration of subsurface geochemical systems at the end of the mining cycle. The primary concern is the restoration of the aquifer and host rock. Specifications for subsurface restoration are based on generic regulatory standards and site-specific standards established after an extensive environmental baseline study, and may vary considerably from state to state. Jurisdiction over restoration procedures and regulatory compliance may originate from any combination of local, state and federal agencies, depending on the geographic location of the project.

Surface restoration requires returning the land to its original condition. This is usually not a difficult task, since the surface has not been disturbed by deep trenching or open-pit mining. Buildings, foundations, and process equipment, including wellfield piping, obviously must be removed. Well casing, tubing, and pumps are completely removed from each drill hole and the hole is sealed to within a few feet of the surface. Liquid effluent left over from plant cleanup may be disposed of by natural evaporation or by injection into a deep disposal well designed and approved for that purpose. Pond liners (if any) and contaminated equipment, building material and yard dirt may be buried on-site or at a special disposal site approved by the regulatory agency. Restoration is concluded by reseeding all areas affected during the life of the project.

Restoration of the subsurface geochemical system is a more complicated and time-consuming operation, the object of which is to reduce the effects of leaching as much as is practical. Several techniques are available, depending upon the nature of the task. The most commonly used technique is to reverse the direction of most injection wells to maintain steady pumping of residual fluids out of the area encompassed within the well field. Normal groundwater flow will gradually replace the water pumped to the surface. By regulating the pumping sequence, a sweeping action can be developed which will eventually remove the last traces of lixiviant and its effect from the aquifer and the host rock. Continual laboratory testing is necessary to determine the point at which groundwater conditions have reached a normal state, or at least an environmentally acceptable state, before pumping can be terminated. Ideally, groundwater pumped to the surface is treated to remove undesirable chemicals and reinjected into the aquifer to hasten the restoration. Waste-stream materials concentrated by this process are disposed of by evaporation or deep well injection.

The injection of special fluids into the aquifer may be required under more severe conditions of contamination. If such contamination goes undetected, restoration problems and costs may become extreme. The special fluids, designed to correct and stabilize a chemical imbalance, will expedite recovery of lixiviant ions that may become attached to clay particles, or reduce the dissolving of particles unfavorable to the ISL recovery system. In this situation, it may be necessary to specially treat the returned fluids to remove contaminants. The processes of electrodialysis/ion exchange and reverse osmosis are the two most commonly used. The waste streams from such processes are permanently disposed of by evaporation or deep-well injection.

© NUEXCO 1986

Monitoring Program

Each solution mining project must have a monitoring program in place before commercial operations begin. The purpose of a monitoring program is to establish a record of natural environmental conditions before mining begins in order to estimate the potential impact the project may have on the local environment. In fact, the monitoring program is maintained throughout the life of the project and for an indefinite period afterward, depending upon the level of success attained in restoration. Every monitoring program is designed according to specifications contained in regulatory requirements. Regulations developed to maintain an environmental balance for the project area become an integral part of operational procedures.

Prior to mining, surface monitoring studies determine prevailing environmental conditions and the potential impact of surface construction and plant operation on air, soil, erosion by wind and water, fauna and flora, and surface water quality. Permanent sample stations are built for this purpose. Subsurface standards are established for control of groundwater quality. This is accomplished by drilling a pattern of wells into the aquifer containing the ore deposit. Wells are also drilled inside the ore deposit to determine water quality prior to mining. Restoration standards for the aquifer are established on this information. Water quality monitoring wells are also drilled around the outer limits of the area to be mined. These wells are placed to provide continual checking for excursions of lixiviant during the leaching phase. The number of monitoring wells drilled, and the sampling procedures used, are usually determined by the principal regulatory agency. The mine operator is obligated to maintain each monitor well and surface station, supported by formal written reports sent directly to the regulatory agency.

The mine operator is also required to establish a radiological monitoring program to take effect as mining begins. Determination of natural background levels for selected radionuclides, including, gross alpha/beta, radon-222, radium-226, thorium-230, and U_3O_8, is established as a guideline before mining begins. Sampling devices must be provided to monitor chemical and radiological contamination that may occur from the accidental release of atmospheric and liquid effluents in and around the plant site. Radioactivity and dust levels in all workplaces are monitored constantly. The object of this monitoring is to reestablish the natural background level of radionuclides during postmining restoration. Once restoration to pre-determined levels has been accomplished, monitoring continues for at least one year to verify success.

Conclusion

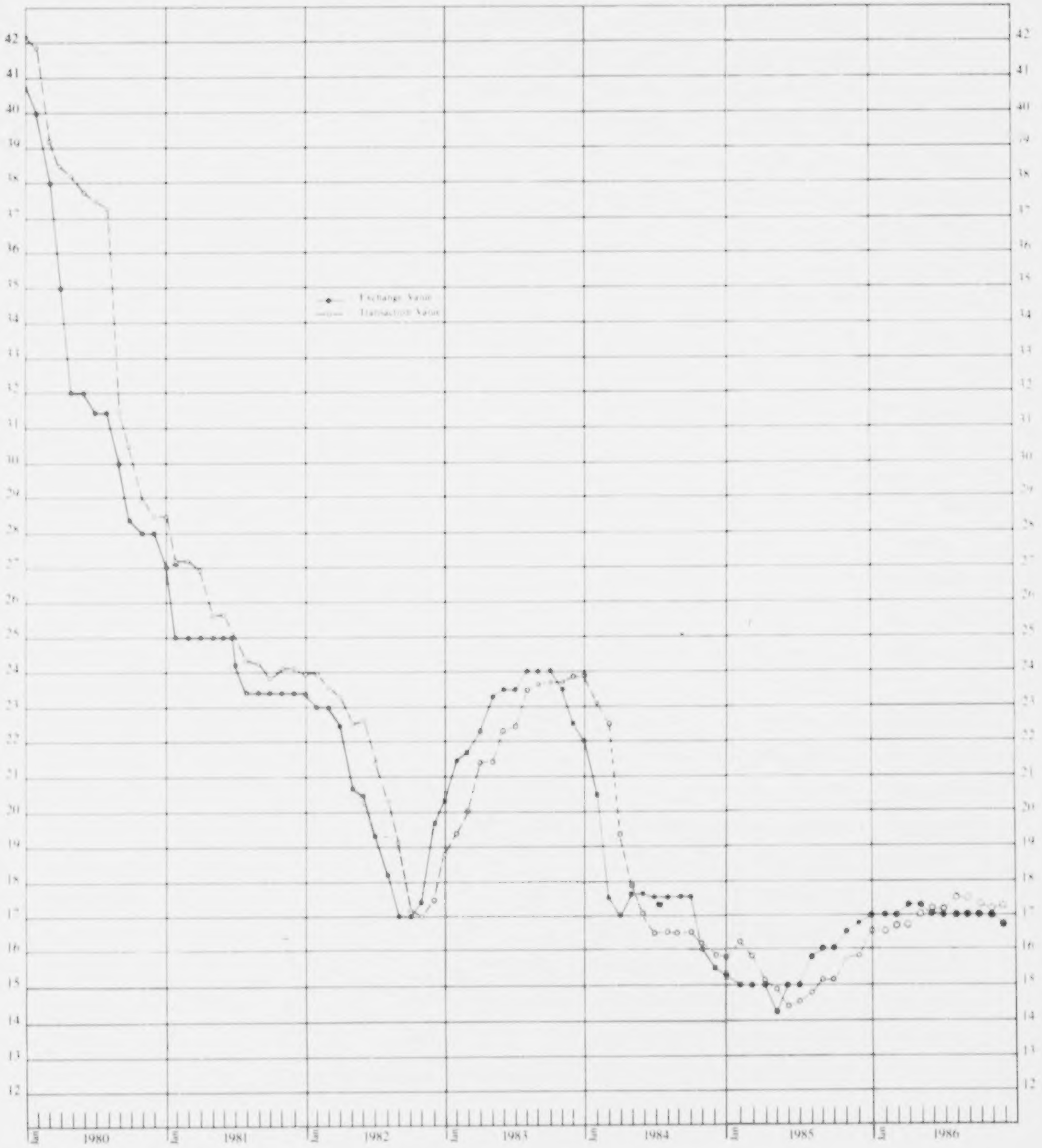
, Solution mining presents an increasingly attractive technique for mining some types of uranium ores commonly found in the USA. Although application of this method requires specific geological conditions to be successful, it is especially economical for extracting ores containing a low concentration of uranium. Given the economics of mining in today's market for uranium and the current environmental regulatory climate, solution mining can be expected to supply an increasing percentage of US uranium in the years to come. Part 2 of this article will address specific solution mining projects in the USA.

© NUEXCO 1986

HISTORICAL MARKET DATA

EXCHANGE AND TRANSACTION VALUES SINCE JANUARY 1980

Determined as of the last day of the month indicated



© NUEXCO 1986

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	**16.75**	

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	**17.30**	

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	**1.80**	

© NUEXCO 1986

GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3,4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7R	202.5
Oct 1985	108.4R	202.4
Nov 1985	109.4R	209.9
Dec 1985	110.0R	210.0
Jan 1986	109.6R	210.0
Feb 1986	108.7R	210.0
Mar 1986	99.5R	210.5
Apr 1986	94.3R	210.5
May 1986	93.5R	210.5
Jun 1986	95.7R	210.5
Jul 1986	98.1	215.2
Aug 1986	98.2	215.2

P = Preliminary   R = Revised since last month

[1] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4] Annual averages prior to 1979 reflect index base no longer in use.

[5] Monthly data for 1979-82 appear on page 35 of Report 184.

[6] Annual averages are for financial year ending June 30.

© NUEXCO 1986

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3R	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.6R	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6R	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.7	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.96P	16.13P	15.40	12.97P	11.78P	12.74P
Sep 1986	119.4P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

---

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

© NUEXCO 1986

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140R	516,832R
Aug	1986	—	—	232.2	220.3	760,925	502,968
Sep	1986	81.94P	181.8	236.7	221.9	—	—
Oct	1986	—	—	239.3	—	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1986

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	**All Commodities (1967 = 100)**	**(1967 = 100)**	**(1982 = 100)**	**Metal Mining (SIC 10)**	**Primary Non-ferrous Metals (SIC 333)**	**Chemicals and Allied Products (SIC 28)**	**Electric and Electronic Equipment (SIC 36)**
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8R	299.0R	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.7	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.7	297.2	328.6	—	13.04R	13.18R	11.99R	9.67
Sep 1986	308.8	297.7	330.2	115.0	13.14P	13.43P	12.00R	9.72R
Oct 1986	309.3	298.3	330.5	—	—	—	12.09P	9.67P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.

Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.

Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.

Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

© NUEXCO 1986

NUEXCO

REPRESENTATIVES AND CONSULTANTS

JAPAN

Kazy Yokota

Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson

Southern Prospecting (Pty) Limited
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telephone: (27-11) 838-1868
(27-11) 834-4211
Telecopy: (27-11) 834-3148
Telex: 4-89878 SA

TAIWAN

Edward Bee

Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg

83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

Ralph O. Smith

141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

SPECIAL CONSULTANTS

George J. Stathakis
International Investment Banking

James C. C. Stewart
U.K. Nuclear Industry

W. Bryan Webster
International Business Development

J. Robert Wolcott
International Business Development

NUEXCO

EXECUTIVE SUMMARY
REPORT 220
(All data as of November 30, 1986)

Exchange Value
$16.75, down $0.25

The **Exchange Value** is **$16.75** per pound U_3O_8, down $0.25 since last month.

UF_6 Value
$48.00, unchanged

The **UF_6 Value** is **$48.00** per kilogram U as UF_6, unchanged since last month.

Transactions

Six recent natural uranium sales are reported, involving approximately **750 thousand** pounds equivalent U_3O_8 in the near term, and approximately **5 million** pounds equivalent U_3O_8 in the longer term. Five of the sales involved spot or near-term delivery, and four met the conditions for inclusion in the Transaction Value. Four of the transactions involved natural UF_6.

Supply-Demand Ratio
increased to 5.9:1

Active spot and near-term **uranium supply** amounts to **4.5 million** pounds U_3O_8 equivalent, up 790 thousand pounds since last month. Active spot and near-term **uranium demand** totals **770 thousand** pounds, down 180 thousand pounds. The spot and near-term **supply-demand ratio** increased to **5.9:1.**

Transaction Value
$17.30, up $0.05

The **Transaction Value** is **$17.30** per pound U_3O_8, up $0.05 since last month. The calculation includes 13 transactions involving a total of 2.0 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate
unchanged at 4%

The **Loan Rate** is **4 percent** per annum, unchanged.

Conversion Value
$1.80, down $0.10

The **Conversion Value** is **$1.80** per pound U as UF_6, down $0.10 since last month. Active secondary market supply for conversion services for delivery within three years totals 1.4 million pounds U as UF_6. Active demand totals 650 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

SWU Value for
delivery within
one year: $80, up $2

The **SWU Value** at .3 tails and for delivery within one year is **$80** per SWU, up $2 since last month. Three secondary market SWU transactions are reported, involving approximately 200 thousand SWUs.

* * *

Analysis and
Commentary

Despite its floor price policy, Australia is moving back into the forefront of uranium supply nations. This article discusses the supply positions of ERA, Olympic Dam, and Queensland Mines, as well as uranium policies and politics in Australia.

Basic Considerations

The Thorium High-Temperature Reactor (THTR 300) in the Federal Republic of Germany (North-Rhine Westphalia) reached its rated power of 300 MWe in September. The unit is the prototype plant in Germany's High-Temperature Reactor program.

United States

The Energy Information Administration (EIA) has just released its 1985 viability assessment of the US uranium mining and milling industry. Energy Secretary Herrington will use the study in his determination of the uranium industry's viability for 1985. Figures from the latest assessment generally indicate that the industry is in a poorer condition than it was in 1984, when it was determined to be nonviable, so Secretary Herrington will almost certainly repeat that finding for 1985.

Raw Materials

This is the first part of a two-part article on solution mining of uranium. Solution mining has developed into a cost-effective and environmentally attractive mining process, especially for the low-grade reserves often found in the USA.

This Executive Summary may be reproduced for internal distribution.

© NUEXCO 1986

NUEXCO

NUEXCO REPORT 220 FIGURES OF THE MONTH (November 30, 1986)	This Month (Report 220)	Last Month (Report 219)	12 Months Ago (Report 208)
Exchange Value[1]	16.75	17.00	16.75
Transaction Value[1]	17.30	17.25	15.80
UF_6 Value[2]	48.00	48.00	46.00
Loan Rate[3]	4%	4%	5%
Conversion Value[4]	1.80	1.90	1.60
Near-Term Uranium Supply[5]	4.5	3.7	3.6
Near-Term Uranium Demand[6]	0.8	1.0	2.3
Near-Term Supply-Demand Ratio	5.9	3.9	1.6
Recent Uranium Sales:			
Number of Transactions[7]	6	6	1
Quantity of Material[8]	0.8	1.0	0.2
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	78	78
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	—	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	458	451
3.0 w/o U_{235}	588	586	578
3.5 w/o U_{235}	719	717	707
4.0 w/o U_{235}	852	849	837

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (219)

Section	Topic	Page
Analysis and Commentary	Effects of the Chernobyl Accident on Worldwide Nuclear Power Programs	11
Essay	Chernobyl in Perspective	19
South Africa	Third-Quarter Figures from Chamber of Mines	22
Switzerland	Swiss Parliament Affirms Nuclear Program	22
United States	Congress Approves Revised Enrichment Criteria	23
Focus	The Price-Anderson Act	25
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in October 1986	1
	Enriched Uranium and SWUs Pricing in October 1986	2

1/20/87 B6800-1

NUEXCO

JANUARY 1987

NUMBER 221

MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

Three Park Central   1515 Arapahoe Street, Suite 1045   Denver, Colorado 80202

HEADQUARTERS

Chairman of the Board of Partners
Oren L. Benton

Vice Chairman of the Board of Partners
Samuel R. Freeman

Directors of Operations
Business and Financial Affairs — James E. Lewis
Administration — J. Fred Lawrence
Legal and Regulatory Affairs — Frederick J. Boyne

NUEXCO FUEL BROKERAGE SERVICES

Manager of Fuel Brokerage
Earl E. Hoellen, Jr.

BROKERAGE SERVICE LOCATIONS

UNITED STATES

DENVER
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

Managing Broker
Earl E. Hoellen, Jr.

MENLO PARK
Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

Managing Broker
George White, Jr.

EUROPE

FERNEY-VOLTAIRE
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

Managing Broker
James E. Vaughan

ZURICH
135 Zurichstrasse
CH-8700 Kusnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

Managing Broker
Donald P. Ebright

REGIONAL MANAGING BROKERS

AFRICA
James E. Vaughan

AUSTRALIA
George White, Jr.

FAR EAST
Earl E. Hoellen, Jr.

NORTH AND SOUTH AMERICA
Earl E. Hoellen, Jr.

(See inside back cover for list of Representatives and International Advisory Committee)

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

January 1987 No. 221

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 1

CURRENT MARKET DATA

Nuexco Market Values 2
Nuexco Market Values Expressed in Selected Currencies 3
Recent Transactions 5
Supply and Demand Tables 6

ESSAY

The South Africa Situation by J. R. Wolcott 11

RECENT DEVELOPMENTS

United States 16

FOCUS

The Nuclear Waste Policy Act of 1982 18

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 22
Historical Exchange Value, Transaction Value and Conversion Value 23
Graph of World Uranium Production 24
US Uranium Marketing Activities Statistics 25
Volume and Price of Uranium Deliveries to the European Community 26

GOVERNMENT STATISTICS

Australia 27
Canada 28
South Africa 29
United States 30

INDEX TO 1986 MONTHLY REPORTS 31

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein.

© NUEXCO 1987

To Our Readers

In this Report, Nuexco has made some additions to our *Historical Market Data* section, beginning on page 24. As a service to our subscribers, we have gathered some of the more useful general information on the nuclear fuel market available in a number of different publications. Although available elsewhere, we believe that compiling some of the more interesting statistics in a single format will enhance this section of the Monthly Report. The sources of the information are well-known, and include the Euratom Supply Agency, the US Energy Information Administration, and the OECD Nuclear Energy Agency. We hope you find this data valuable and an interesting addition to the historical Nuexco Market Values.

The graph representation of world production was taken from "Uranium — Resources, Production and Demand," the joint report issued by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. The table listing the average volume and price of natural uranium deliveries to European Community member nations was excerpted from the Euratom Supply Agency Annual Report. The table showing US uranium marketing activity statistics was compiled from various tables in the "Uranium Industry Annual," published by the US Energy Information Administration.

* * *

Nuexco is pleased to announce two acquisitions that will serve to enhance our capabilities for customer service.

1. Our acquisition of Colorado Nuclear Corporation will complement our service capabilities in the area of market information and consulting.

2. Our acquisition of the *International Directory of Nuclear Utilities* will augment our publishing services. Formerly produced and published by Lotte Ltd., of Lakewood, Colorado, the Directory contains the names, addresses, and telephone/telex numbers of utilities operating nuclear plants, as well as names and titles of technical and administrative managers, and other valuable information. The current Directory can be purchased from Nuexco by writing or calling Lori Costarella at our headquarters in Denver, Colorado (303-893-4015).

© NUEXCO 1987

NUEXCO

January 1987
#221

PRICING

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of December 31, 1986)

The **Exchange Value** is **$16.75** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **4,145,000** pounds U_3O_8 equivalent, down 385 thousand pounds since last month. The corresponding figure for **active demand** is **800,000** pounds, up 30 thousand pounds. The spot and near-term **supply-demand ratio** decreased to **5.2:1.**

The *Current Market Data* section of this Report lists one natural uranium sale, involving approximately 100,000 to 300,000 pounds U_3O_8 equivalent. This transaction involved spot or near-term delivery, and met the criteria for inclusion in the current Transaction Value calculation. One loan transaction is reported, involving 100,000 to 300,000 pounds U_3O_8 equivalent.

The **Transaction Value** is **$17.35** per pound U_3O_8, up $0.05 since last month. The calculation extends over a 4-month period and includes 14 transactions involving 2.1 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, down $0.25 since last month.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 750 thousand pounds U as UF_6. Active demand totals 900 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

The **Loan Rate** is **4 percent** per annum, unchanged.

* * *

The Exchange Value remained unchanged at $16.75 as the market showed little activity during December. Only one sales transaction is reported. Demand for natural uranium concentrates remains weak, but increased slightly to 800 thousand pounds equivalent U_3O_8. Supply decreased by nearly 400 thousand pounds during December, causing the supply/demand ratio to decrease slightly, to 5.2:1.

The market for natural UF_6 was largely inactive during December. The UF_6 Value, however, declined slightly to $47.75. The UF_6 market, in particular, continues to show a large spread between the prices buyers are willing to pay, and the prices sellers are willing to accept. Buyers are reluctant to commit to new purchases at this time, and so the discretionary nature of demand is continuing to exert downward pressure on the market.

The most important single factor influencing the market is still the possibility of import restrictions being placed on non-US-origin material, as a consequence of the uncertainties surrounding the US uranium producers vs. DOE lawsuit. By year's end, no ruling had been made by the Tenth Circuit Court of Appeals, but rumors predicting the imminent issuance of such a ruling substantially inhibited both buying and selling during December.

US-origin material currently commands a premium of $0.75 per pound U_3O_8 (up $0.10) in the form of concentrates, and $2.50 per kilogram U in the form of UF_6. Most of the US-origin material sold in the last several months has been made available by means of origin-swap transactions, although there appears to be a decrease in the supply of US-origin uranium available for swap transactions. Asking prices of US producers remain somewhat higher than the Exchange Value, pending a resolution of the producers' lawsuit vs. DOE, which many expect to favor the US uranium industry.

* * *

The Conversion Value was unchanged this month at $1.80, as demand remains thin. The secondary market for conversion services continues to be largely inactive, even though conversion supply has declined and supply has increased. No conversion transactions are reported.

* * *

ENRICHED URANIUM AND SWUS

The **SWU Value** as of December 31, 1986, is $80 per SWU, unchanged since last month. This refers to SWU at a tails assay of 0.30 weight-percent U_{235} and for delivery within one year. The SWU market showed little or no activity during December, with no secondary market SWU transactions being reported.

The SWU market continues to exhibit a fairly wide spread of prices, depending on variables such as origin, delivery and notification dates, whether contract SWU or SWU contained in enriched product, quantities available, and terms of payment. Small quantities of DOE-origin virgin SWUs are still available at prices between $85-100. SWUs contained in enriched product generally are available in larger quantities, at prices near the current SWU value.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

December 31, 1986	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.75**/lb. U_3O_8	4,145	800
UF_6 VALUE	**$47.75**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	750	900
SWU VALUE 0.3 tails assay; delivery within one year	**$80**/SWU		
LOAN RATE	**4%**/annum	220	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	17.35	2.1	14	4

[1] Supply and demand tables in *CurrentMarket Data* section of this Report detail the numbers for each category

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantitis of natural uranium concentrates could be concluded as of the date inlicated
2. The **UF_6 Value** is Nuexco's judgmen of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of ne date indicated
3. The **Conversion Value** is Nuexco's udgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the seconlary market as of the date indicated
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significantquantities of SWU's of stated origin for delivery in the specified time period could be concluded as of the date indicated
5. The **Loan Rate** is Nuexco's judgmert of the annual interest rate at which uranium loans could be concluded a of the date indicated
6. The **Transaction Value** is a weighed average price of recent natural uranium sales transactions. The calculation is based on prices paid in
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date.
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent

   The sample time is extended as necesary to include these minima. Other currencies are converted to U.S dollar using conversion rates in effect on or near the transaction date

DERIVATIONS AND COMMENTS

1. All Market Values are based on
   a. Data from recently completed transactions
   b. Data from pending transactions
   c. Firm bids to buy or borrow, and firm offers to sell or lend
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services
4. The prices of conversion services or SWU's delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined

© NUEXCO 1987

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**
Australia (dollar)	25.21	25.85	24.92	65.55	67.20	64.78
Belgium (comm. franc)	678.06	694.16	854.70	1.763	1,805	2,222
Canada (dollar)	23.16	23.22	23.78	60.20	60.36	61.81
EEC (ecu)	15.73	16.16	19.16	40.90	42.02	49.80
Finland (markka)	80.65	82.31	92.19	209.68	213.99	239.68
France (franc)	108.00	108.98	128.40	280.77	283.32	333.81
FRG (mark)	32.58	33.27	41.87	84.70	86.50	108.86
Italy (lira)	22,681	23,116	28,509	58,966	60,097	74,117
Japan (yen)	2,677	2,715	3,413	6,961	7,059	8,873
Netherlands (guilder)	36.85	37.86	47.16	95.81	98.43	122.60
South Africa (rand)	36.81	37.64	43.87	95.71	97.86	114.05
Spain (peseta)	2,219	2,254	2,621	5,768	5,859	6,815
Sweden (krona)	114.10	115.68	128.98	296.64	300.73	335.33
Switzerland (franc)	27.22	27.69	35.31	70.76	71.98	91.79
UK (pound)	11.40	11.75	11.82	29.64	30.55	30.73
US (dollar)	16.75	16.75	17.00	43.55	43.55	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**
Australia (dollar)	26.12	26.70	24.26	67.90	69.41	63.07
Belgium (comm. franc)	702.34	716.95	832.08	1,826	1,864	2,163
Canada (dollar)	23.99	23.98	23.15	62.36	62.34	60.18
EEC (ecu)	16.30	16.69	18.65	42.37	43.40	48.49
Finland (markka)	83.54	85.01	89.75	217.19	221.01	233.33
France (franc)	111.86	112.56	125.00	290.82	292.62	324.97
FRG (mark)	33.75	34.37	40.76	87.73	89.34	105.98
Italy (lira)	23,494	23,875	27,754	61,078	62,070	72,155
Japan (yen)	2,773	2,804	3,323	7,210	7,291	8,638
Netherlands (guilder)	38.17	39.10	45.91	99.24	101.66	119.35
South Africa (rand)	38.13	38.88	42.71	99.13	101.07	111.04
Spain (peseta)	2,298	2,328	2,552	5,974	6,052	6,635
Sweden (krona)	118.19	119.48	125.57	307.26	310.61	326.45
Switzerland (franc)	28.19	28.60	34.37	73.30	74.34	89.36
UK (pound)	11.81	12.14	11.51	30.71	31.55	29.92
US (dollar)	17.35	17.30	16.55	45.11	44.98	43.03

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Dec 31, 1986

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**	**This Month (Dec 31, 1986)**	**Last Month (Nov 30, 1986)**	**12 Months Ago (Dec 31, 1985)**
Australia (dollar)	2.71	2.78	2.35	5.97	6.12	5.17
Belgium (comm. franc)	72.87	74.60	80.44	160.64	164.46	177.34
Canada (dollar)	2.49	2.49	2.24	5.49	5.50	4.93
EEC (ecu)	1.69	1.74	1.80	3.73	3.83	3.98
Finland (markka)	8.67	8.85	8.68	19.11	19.50	19.13
France (franc)	11.61	11.71	12.08	25.59	25.82	26.64
FRG (mark)	3.50	3.58	3.94	7.72	7.88	8.69
Italy (lira)	2,437	2,484	2,683	5,373	5,477	5,915
Japan (yen)	287.72	291.78	321.22	634.32	643.27	708.17
Netherlands (guilder)	3.96	4.07	4.44	8.73	8.97	9.78
South Africa (rand)	3.96	4.04	4.13	8.72	8.92	9.10
Spain (peseta)	238.41	242.20	246.72	525.60	533.95	543.93
Sweden (krona)	12.26	12.43	12.14	27.03	27.41	26.76
Switzerland (franc)	2.93	2.98	3.32	6.45	6.56	7.33
UK (pound)	1.23	1.26	1.11	2.70	2.78	2.45
US (dollar)	1.80	1.80	1.60	3.97	3.97	3.53

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Dec 31, 1986)**	**UF_6 Value per kg.U in UF_6 This Month (Dec 31, 1986)**	**UF_6 Value per kg.U in UF_6 Last Month (Nov 30, 1986)**
Australia (dollar)	120.43	71.88	74.07
Belgium (comm. franc)	3,238	1,933	1,989
Canada (dollar)	110.60	66.01	66.53
EEC (ecu)	75.14	44.85	46.32
Finland (markka)	385.21	229.92	235.87
France (franc)	515.80	307.86	312.30
FRG (mark)	155.60	92.87	95.35
Italy (lira)	108,328	64,658	66,243
Japan (yen)	12,788	7,633	7,781
Netherlands (guilder)	176.02	105.06	108.50
South Africa (rand)	175.82	104.94	107.87
Spain (peseta)	10,596	6,325	6,459
Sweden (krona)	544.96	325.27	331.49
Switzerland (franc)	130.00	77.59	79.34
UK (pound)	54.46	32.50	33.67
US (dollar)	80.00	47.75	48.00

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Dec. 31, 1986.

© NUEXCO 1987

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3906	1987	101-300	R[5]	Trader	Utility	

Loan Transactions

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Loan Rate	Lender	Borrower	Remarks
3883	1986	101-300	R[5]	Utility	Trader	Contained in low-enriched uranium

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

URANIUM SUPPLY
(December 31, 1986)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale: **ACTIVE**			
2335	400	—	
2740	100	—	
2885B	230	—	UF_6
2893A	480	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2975	250	—	
2989	40	—	
2990	130	—	UF_6
2996*	500	500 per year	1988-90
3023	500	500	UF_6
3121	500	—	
3129	500	500	
2263	—	400 per year	1988 on
2781*	—	750 per year	1988-95
2981	—	600 per year	1988-91
TOTAL:	4,145		
INACTIVE			
2297	200	200 per year	1988-89
2336	250	250 per year	1988-94
2389	75	75 per year	1988-90
2764*	260	—	UF_6
3128	100	—	
2625*	—	500 per year	1988 on
TOTAL:	885		

---

*New or revised since last month

[1] Measured from the date of this Report

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near term contracts.

Projects removed since last month: 2777, 2880, 2927

© NUEXCO 1987

URANIUM DEMAND
(December 31, 1986)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2878B*	30	—	UF_6
2956	350	350	U_3O_8 or UF_6
2977	105	—	UF_6
2984	145	—	UF_6
2991	105	—	UF_6
3075	65	—	
2738	—	1,000	1989 on
2962	—	500	1989 on
2985	—	675 per year	1992 on
3097	—	300 per year	1988 on
TOTAL:	800		
INACTIVE			
2760	750	750 per year	1988-90
2798	70	—	
2948	100	—	UF_6
2936	—	400 per year	1988-95
TOTAL:	920		

---

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 3019.

© NUEXCO 1987

CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(December 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
2861*	220	—	UF_6
TOTAL:	220		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2920	2,000	—	
TOTAL:	4,500		

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 2667.

No inquiries to borrow are reported this month.

© NUEXCO 1987

CONVERSION SUPPLY AND DEMAND
(December 31, 1986)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF₆) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
2859	750	750	
TOTAL:	750		
Available for Sale: INACTIVE			
2988*	165	—	
TOTAL:	165		
Inquiries to Purchase: ACTIVE			
2949	250	—	
2997*	650	—	
TOTAL:	900		
Inquiries to Purchase: INACTIVE			
2833*	400	—	
TOTAL:	400		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: 2935.

© NUEXCO 1987

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(December 31, 1986)

	Delivery Period[1] (Thousands of SWUs)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale: ACTIVE			
2571*	—	55	
3156	70	—	1987
TOTAL:	70		
Inquiries to Purchase: ACTIVE			
2987	100	—	1987-88
3015	40	—	
2878*	65	—	1987
2999*	150	—	
TOTAL:	355		
Inquiries to Purchase: INACTIVE			
2879	250	—	
TOTAL:	250		

*New or revised since last month

[1] Measured from the date of this Report

[2] For delivery within one year. This category excludes SWU's deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2855

© NUEXCO 1987

ESSAY

THE SOUTH AFRICAN SITUATION

By J. Robert Wolcott
Chairman, Nuexco/Concord International
Advisory Committee

Mr. Wolcott, the former Chairman of Nuexco, is now Chairman of the Nuexco-Concord International Advisory Committee. He has followed South African developments for some time: partly because of several visits; partly because of participation in the nuclear fuel industry; and partly because South Africa has been singled out for attention. Sanctions, disinvestments, disengagements, and withdrawals (such as those of Coca Cola, General Motors, IBM, Honeywell, etc.) have been interpreted by some to be "watershed" events. While watershed may, or may not, be an apt description, events do suggest it is an appropriate time for a discussion of the South African situation. Opinions will, of course, differ. Mr. Wolcott's opinions, as outlined in this essay, are mainly set forth to stimulate thought and discussion.

A Divided Society

My first visit to South Africa convinced me it has the world's most complex social, economic, political and military makeup. No other nation has a comparable racial, cultural, ethnic, tribal, and language mix. Subsequent visits only served to reinforce those first impressions. The nation's problems have reached a new, and perhaps, acute stage.

Much more than race is involved. The country is fragmented in many ways. Some disunity and conflict would be unavoidable, even without racial divisions. For example, anthropologists claim language is one of the greatest, if not the greatest, obstacle to political unity and, thus, is most influential in determining national boundaries. Had borders been set wherever languages change, South Africa would be dozens of nations.

South African society has three vertical layers, with divisions within each layer. The result is a pyramid that is segmented vertically and horizontally. The top layer consists of four million whites; the middle layer two million so-called coloreds; and the bottom layer is occupied by the country's 18 million blacks.

The white layer is divided by language and culture. Afrikaners, mainly of Dutch descent, have lived in South Africa for centuries, are strong in farming, politics, and government and tend to maintain a more hard line apartheid policy. English speaking South Africans, mainly of British descent, are strong in mining, industry, and finance and are generally more liberal on apartheid policy.

The middle layer, so-called "coloreds," includes Indians, Chinese, Japanese, and others of lighter color or mixed blood. Indians (mainly descendants of India) comprise the largest group (around 600,000). Coloreds tend to identify more with whites than blacks, although they are neither fully comfortable with, nor accepted by either. Coloreds have neither the numbers nor the means of self-protection as a separate group and could be the most vulnerable in any unstable situation.

The bottom layer, by far the largest, consists of blacks, who for the most part belong to one of more than a dozen major tribes. There are also many small tribes. Over 250,000 are contract workers from a variety of African nations. Another million or so are illegal immigrants. Tribal identities, languages, cultures, and ruling systems may be centuries old. Before identifying as South Africans, members usually identify with tribes (Zulu, Xhosa, Hottentot, etc.). The largest tribe is the Zulu, with a membership of over six million.

Ideology is an increasingly divisive influence. Bishop Tutu "hates capitalism," favors sanctions, but looks to the West for support. The African National Congress (ANC), a rebel Marxist-led group, wants black control, nationalization of major industries, a multi-racial society and is backed by the Soviet Union. The Zulu, Chief Buthelezi, a moderate, opposes apartheid, opposes sanctions, and believes in gradualism and cooperation with whites and the West. The main white opposition party, the Progressive Federal Party (which holds 26 of 166 seats in Parliament), opposes apartheid, opposes sanctions and is unable to agree on the role whites and minorities should play when apartheid is abolished.

Strategic Considerations

Four conditions make South Africa one of the world's most strategically important countries. They are (a) geography, (b) physical resources, (c) role in the comprehensive southern African economic and industrial system, and (d) trained talented people.

South Africa's geography provides the key to control of one of the world's most important shipping lanes. Every year 25,000 ships pass the Cape of Good Hope; a large fraction stop at South African ports, partly to pick up and leave shipments for African nations to the north of South Africa; and about one-third are oil tankers supplying Europe and Japan. One can readily appreciate the power associated with such a geographical position.

South Africa is uncommonly rich in strategic materials. It is the second largest producer, after the USSR, of manganese; leading producer of platinum; second largest producer of chrome, after the USSR; and a major producer of gold, diamonds, coal, uranium, iron ore, vanadium, nickel, tin, lead, and other vital resources. Together, the Soviet Union and South

© NUEXCO 1987

Africa virtually control the world's supplies of chrome, platinum, and vanadium. They are also the major producers of some others, such as gold. New mineral "OPEC's" could arise if the control of South Africa's resources changed hands.

South Africa, with less than 10% of the African population, produces 40% of the GNP. Not only is South Africa the only African nation self-sufficient in food supply, but it is also an exporter. White living standards are comparable to those in the West. Black economic levels are three times the average of sub-Sahara African nations. Environmental and ecological preservation far surpasses the balance of Africa where animals, grazing land, and farm land are increasingly endangered. Education and training are well above averages for the rest of the continent. Africa needs those human resources — both for South Africa, and for the benefit of the balance of Africa as well.

South Africa is the economic hub of the whole of Southern Africa. Most countries near South Africa are landlocked and depend heavily upon South African transportation, communication, markets, technology, and capital. Without a viable South African economy, all of southern Africa cannot have a viable economy.

Government Policies

Government strategies and policies will be decisive in determining South Africa's future, but it is not clear which government policies will be decisive. Self-interests are varied and policies conflict in many ways. The most important government policies are those of South Africa itself, the two superpowers, and neighboring nations, such as Namibia, Botswana, Zimbabwe, Lesotho, Angola, and Mozambique.

South Africa — The South African government's ineptitude makes it difficult for even those sympathetic to its complexities. Figuratively speaking, the Botha government shoots itself in the foot at every opportunity. But governmental clumsiness cannot be allowed to obscure the need for policies based more on reason than emotion.

The South African government has two fundamental, interrelated problems. The first is that voting rights are limited by race. Only whites, a 16% minority within the total population, are eligible to vote. That eligibility for the vote is determined by race highlights injustice in a way that other voting limitations do not. That violation of democratic principles is probably not the basis for much of the criticism being leveled at South Africa (except, perhaps, in the United States). At least three-quarters of the world is less democratic. Many of those criticizing South Africa, especially other African nations, cannot argue the case for increased democracy without undermining the legitimacy of their own governments.

Enlarging voting eligibility is not a simple act with predictable consequences. Implementation of the one man, one vote principle would be an enormous threat to the existing power structure in South Africa. White voters would be outnumbered by four or five to one. Drastic, unpredictable changes would have to be expected. Whites' desire for gradualism is understandable.

The second fundamental problem is apartheid — that is, separation of living areas, public accommodations, compensation standards, job and professional opportunities, and so on, by race. Although the system has not been dismantled, it has been improved. "Petty apartheid," has gradually declined. More mixing in hotels and other public places is evident. Gradual abolition of separation appears to be the course, although the pace is too slow to please African nations, western critics, or South Africa's black majority.

My own view is that the South African government would move more rapidly in directions promoted by the West if it knew how to do so with a reasonable certainty of a controllable outcome. Neither the West, nor others, have been helpful with practical solutions. Rather, the West has been more than helpful in supplying criticism. The South African government does manifest an unfortunate amount of belligerent intransigence. However, their reaction is somewhat understandable, because the problem is serious and the stakes are high.

The United States — United States foreign policy has become almost the exact opposite of the founding fathers' original intent to "avoid all entangling alliances." For many years, the internal affairs of a nation were viewed as the exclusive business of that nation. That policy gradually eroded as stability and security of strategically-situated nations and regions affected the superpowers' national security.

Concern with other nations' internal affairs became a centerpiece of US foreign policy under the Carter administration. US policies and relationships with other governments were, in theory, to be shaped by their performance on human rights issues. Because human rights vary with circumstances, no objective standards can be applied. For example, the recent US law imposing sanctions against South Africa requires an evaluation by the US government of conditions for blacks in South Africa, but not blacks in the balance of Africa where economic and material conditions are often worse. Uneven degrees of strategic importance from nation to nation makes the application of policy uneven.

By focusing on the human rights issue we allow the issue of South Africa's strategic importance to be subordinated. But by taking upon ourselves the responsibility for a problem for which we cannot provide a suitable solution, we sow the seeds of our own frustration. The result is what I call "a policy of frustration."

© NUEXCO 1987

The Soviet Union — It would be unreasonable to blame the Soviet Union for South African strife, even though it contributes. Sovietologists point out that Soviet superpower status depends totally upon military strength. The Soviet brand of communism is no longer generally accepted as a model for either economic development or social justice; nor do technology, culture, or consumer products provide distinction for leadership. Potential Soviet contributions to a regime consist of (a) military support, and (b) knowledge of methods by which to seize and hold power. The Soviet Union excels in those areas, and those skills are appreciated by a number of African nations.

The USSR is perceived as experiencing internal decline. Mr. Gorbachev lends credibility to this with his public programs. It is sometimes argued that concern with internal problems, mainly those having to do with the economy, will lessen the Soviet Union's external expansion and that South Africa may not be pressured.

That is unlikely. History demonstrates that empires continue to expand long after internal decline is recognized. Moreover, considering the strategic importance of southern Africa, even if resource limitations were to reduce the Soviet Union's external involvements, it would be much more likely to abandon less important targets than to forego the opportunity to interfere in South Africa.

Other African Nations — The nations most important to South Africa are those on or near its border. Conversely, South Africa is the nation most important to Namibia, Zimbabwe, Botswana, Mozambique, Lesotho, Angola, and others.

Southern Africa is an interlocked economic system. Most of the aforementioned nations are landlocked and underdeveloped, and depend upon the South African infrastructure for shipping and communications. Many of them also depend upon South Africa for financing, technology, and management skills.

Leaders of several of those nations have expressed willingness to accept the consequences of opposing South Africa's government (while also requesting US aid to compensate for resulting economic losses). However, it is doubtful they have fully considered the likely impact upon their own nations. The economic viability of southern Africa depends extensively upon the viability of South Africa. And that depends on its social and political viability.

South Africa's border is long and vulnerable, particularly to the Marxist nations of Zimbabwe and Mozambique. Mozambique accommodates the rebel African National Congress (ANC), while South Africa supports rebels opposing the government of Mozambique. Zimbabwe is sympathetic to virtually all anti-South African rebels. To the north of Namibia and Botswana, the Soviets and Cubans are active in Angola. Southern Africa would be a politically explosive region, even without the special problems of South Africa.

Zimbabwe, formerly Rhodesia, made the transition from white rule to black in the late 1970's. One would expect Zimbabwe to be promoted as a model, but that has not been the case in the West. The differences between Zimbabwe and South Africa include a smaller population, smaller percentage of whites, and less difficult tribal conditions, but there are also similarities.

Zimbabwe is not highlighted as a model, no doubt because results have not been as the West would prefer. The largest tribe dominated elections. Minority tribes were violently suppressed. Western nations provided assistance. The few whites retained in government gradually declined in numbers and influence. The prime minister, Robert Mugabe, announced a one-party Marxist system and "everlasting friendship" with the Soviet Union. The West, particularly the United States, is continuously criticized and insulted, so much that 20 million dollars of United States foreign aid recently was suspended. Even former President Carter walked out of a Third World meeting to which he had been invited.

Much of Zimbabwe's industry has been nationalized. Inflation and unemployment are high. Foreign investment is low. East Europeans filled high-salaried, skilled positions vacated by emigrating Rhodesian whites. Amnesty International has been barred for reporting human rights violations. Providing information to Amnesty International has been made a crime.

The Morality Issue

Many people espousing anti-South Africa policies assume that moral superiority is inherent in the imposition of enforced isolation and punitive actions damaging to the nation's economy and to national pride. A further underlying assumption is that South Africa's government can be punished without undue damage to individuals, and even if that is not the case, blacks are prepared to accept the price.

Anti-apartheid movements generally focus narrowly on the issue of black versus white. They take the attitude that all other considerations are almost irrelevant. That reasonable men need not be concerned about anything else at this point. That only when the evil of apartheid is gone will a just society be possible. That any deviation from that way of thinking equates to discrimination. Some even use "destroying society to save it" as a rationale for their actions. In such an atmosphere, news media coverage inevitably becomes unbalanced. One death from violence in South Africa receives more coverage than 100 deaths from deliberate starvation in Ethiopia. South Africa receives more media attention, by far, than the entire balance of Africa, even though millions are currently starving and a dozen or more wars are in progress.

©NUEXCO 1987

ESSAY

The general climate is not one which makes rational approaches easy to suggest or to gain acceptability. Rational solutions require recognizing that apartheid is not only there, in place and functioning, but that it is the linchpin around which a society of 25 million people is organized. Being an unfortunate linchpin does not alter reality. The linchpin of any organization cannot be changed easily and should not be changed blindly. The alternatives need to be known.

Concern for all those who actually live in South Africa must be the first priority. The United States, Western Europe, African nations, the Soviet Union, and other outsiders will not have to live with the end results; South Africans must. It is not clear whether what is promulgated by outsiders is to satisfy their interests, or genuinely reflects the true interests of South Africans. We have no accurate polls reporting the full spectrum of their views. The risk is high that the views of the black rank and file are not well understood, and that those of whites and coloreds are simply ignored.

While there is widespread agreement on the desirability of eliminating discrimination, there is little agreement on how to do it (Chief Buthelezi's concern). Nor, most importantly, is there agreement on the political ideology that would shape the post-apartheid era. The United States may know what would please it most; The Soviet Union may know what would please it most; African critics may know what would please them. And South Africans, as a whole, are not of one mind. The multitude of interests do not coincide. A power vacuum is a genuine threat and how it might be filled will be critical.

In short, a moral course requires knowing the goal, the nature of change required to achieve the goal, and a clear vision of how that change will be accomplished. I do not believe anyone, including the United States Congress, can claim moral superiority, until it is known not only what one is for, but what one is against.

Challenges and Responses

South Africa has all the conflicting elements of race, religion, class status, and language, any one of which has set off wars in other places. Henry Kissinger has commented that the potential danger is a situation where everyone ends up fighting everyone, as in Lebanon. Governing South Africa with its many contradictions would be a major challenge under the best of conditions.

Orderly change requires the reasonable continuity of a central government. Without a center of power, the expected results will be chaos. A power vacuum would unleash internal forces, as well as external forces, and could result in anarchy. Chaos would, of course, provide opportunity for foreign intervention. Cubans are nearby. The United States, on the other hand, may have locked itself into a position of impotence. The US public will not support black, Marxist groups, nor will they support white-led forces appearing to support apartheid.

The US Congress has decided that "constructive engagement," as espoused by the Reagan Administration, is a failed policy. A more activist policy involving punitive measures, namely sanctions, is preferred at this point. The effects of sanctions go well beyond legal requirements. The combined effect of South Africa's problems — US government opposition and public opposition — is just too difficult for many US companies. Some have left, and others will follow. Unfortunately from the South African point of view, they certainly will not return before an acceptable solution has been achieved.

Congress is caught up in the need to oppose apartheid to the exclusion of all else, to "be on the right side of history," "to strike a blow for democracy," etc. Consequences, alternatives and the longer view are not considered thoroughly. Slogans are substituted for objectives. The United States is pursuing a mindless policy of frustration, rather than a constructive policy of solution.

The Uranium Situation

South Africa produces about 13% of the world's uranium. Namibia, under South Africa control and included in sanctions, contributes another 10%. World resources are ample for the replacement of all South African supplies. Prices might rise, but that effect would be minimal, and the loss of South African potential supply is not a grave threat.

Uranium business decisions to be made in South Africa will have major impact. For example, a decision to dispose quickly of the 20 to 30 million pounds of inventory at whatever price is attainable would drop the market. If long-term contracts are not renewed and output continues unabated (a likely outcome, as most South African uranium is a by-product of gold production), and if that were sold on the spot market, the impact would be great. Many scenarios are conceivable and most are not too comforting to suppliers in an international market.

Because of the "siege mentality" in South Africa, there has long been a tendency to believe that problems can be overcome by sheer willpower. With certain products which may be traded with little difficulty, such as gold, that may work for a time. On the other hand, uranium is highly controlled. Origin is an important factor. Sooner or later, South Africans must appreciate the complex commercial world in which they now live. Additional commercial assistance will be needed. What form that may take is yet to be determined.

Summary and Conclusions

As severe and unfortunate as its problems may be, South Africa is not the villian it is made to appear. The South African government's handling of sensitive human issues is clumsy, but

© NUEXCO 1987

easy solutions are not evident. The mindless punitive policies now being employed by opponents are most likely to lead from the current situation, in which blacks have no political influence under a white-controlled government, to a future situation in which blacks, coloreds, and whites have no political influence under a black totalitarian government.

To change South African society in a positive direction, promising equality, dignity, and political participation, requires much more than merely eliminating discrimination. It requires a comprehensive vision of a magnitude that I am not aware exists inside or outside South Africa.

The probability of successful results is much greater if the nation's substantial internal social and political pressures are allowed to resolve themselves. That does not guarantee success, but allows those who must live with the results to be responsible for the final outcome. Outsiders, such as the United States, can add only problems without solutions. The West and South Africa need stability, while the Marxists need instability to aid their efforts to usurp control. Too much outside influence may very well facilitate the attainment of their objectives.

A number of American companies have withdrawn and more will follow. The reasons, ultimately, are economic ones. The market is small; profitability is small; the long-term outlook is risky, and public relation problems are large. Disproportionate management time, energy, and resources are absorbed. Few, if any, believe their leaving will contribute to solving apartheid, but rather, they believe the opposite. None will return before a satisfactory solution is achieved, if ever.

United States sanctions do put pressure on South African businesses; they will reduce exports and imports; they will decrease profits; they will hasten the departure of international companies; they will increase unemployment. They will also help radicalize negotiating positions, and we do not know the ultimate result. Results of economic disengagement are not yet known. Hardships resulting from companies' disengagement are beginning to gain modest media attention. Their view of the relative advantages and disadvantages may change with time. There is good reason for companies to wait before joining the movement toward disengagement.

As time goes on, the West may be confronted with what the Soviet political lexicon calls "an objective correlation of forces," which means revolution and communist dictatorship. By the time we know more about the eventual outcome in South Africa, the West may have painted itself into a corner ensuring a power vacuum that would naturally be filled by the Soviet Union.

Current problems in South Africa are viewed as caused by their government, but government also must provide the solution. An orderly system is not possible without government. Weakening government by the various devices now being used in the world decreases the government's ability to deal with its problems, and thereby increases the likelihood of chaos.

I am not totally pessimistic. A middle ground may evolve. The South African government must recognize that indefinite survival is not possible without a base of support from the country's black and colored citizens. Blacks must appreciate the potential consequences of a breakdown in law and order. Coloreds must appreciate the precariousness of their in-between situation. Border nations must appreciate the economic and military risks of an unstable South Africa and the threat of outside domination. Although things may get worse before they get better, a number of rational forces do reinforce one another. Whether they will prevail against the combined forces of the many irrational influences will not be decided soon.

Strategy Recommendations for Market Participants

1. Operate within the constraints of national and international laws.

2. Continue, insofar as possible, business relationships as in the past, and search for new opportunities.

3. Do not feel a moral need to go beyond the actual requirements of the law in dealing with South African matters. Do not use "moral superiority" as a basis to support sanctions and disengagement. Try to take a more long-term, balanced view.

4. Do not invest in South Africa. Do not recommend investment by clients. Both for economic reasons. Risk is high. Prospects for stability and profit do not justify the risk.

5. Keep informed about the numerous constraints which affect commerce in uranium of South African or Namibian origin.

© NUEXCO 1987

UNITED STATES

Following the release in November of the EIA report "Domestic Uranium Mining and Milling Industry: 1985 Viability Assessment," Secretary of Energy John Herrington has officially declared the uranium mining and milling industry in the US not viable for 1985 (see Report 220, December 1986, page 18 for a summary of the EIA report's findings). This is the second consecutive year that DOE has issued a non-viability determination for the US uranium industry, after finding it viable for 1983, the first year of a viability assessment.

The four key attributes of viability used in the EIA study assume that a viable domestic uranium industry is one that can meet domestic requirements, under a variety of scenarios such as a disruption of import supplies, for a future ten-year period. These attributes are:

1. Resource Capability — the ability of domestic economic uranium reserves to supply all domestic needs for a future ten-year period. Analyzing this attribute, EIA found that according to its projections, domestic uranium supply security requirements would be met by US producers through 1996.

2. Supply Response Capability — whether US uranium production capacity is adequate to meet projected domestic nuclear power requirements for a ten-year period. This attribute considers supply capability as the maximum projected uranium production capacity, limited only by technical and engineering constraints on development of facilities once a hypothetical disruption has begun. EIA found that under its "current disruption status" scenario, which assumes a near-term, one-third import supply disruption, the US industry capacity is sufficient to meet requirements. However, under the "projected disruption" scenario, assuming a one-third import supply disruption starting in 1991, the projected maximum domestic production capacity would fall short of cumulative requirements by about five million pounds U_3O_8.

3. Financial Capability — the US uranium industry's ability to obtain the financing necessary to operate production facilities at the level of supply defined under Supply Response Capability. The EIA report found that "nearly all current and expected short-term indicators of the domestic uranium industry's condition are weak in relation to those of recent times." Production is at its lowest level since 1956; investment in domestic uranium exploration, mining, and milling is at the lowest level since 1973, when the US Government began collecting those statistics; the industry experienced losses of over $650 million during 1984-1985; and recent contract prices are much lower than production costs of the great majority of US uranium deposits. Overall, the report found that domestic production capacity could meet requirements under the "current", that is near-term, disruption scenario, but that it would be inadequate during the first two years of the "projected" disruption scenario.

4. Import Commitment Dependency — whether, for any two consecutive year period, actual or projected US uranium requirements will result in over 37.5 percent being supplied by non-US origin uranium currently under contract or option. EIA reports that imports exceeded this percentage in 1982 and 1984, but fell to 34 percent in 1985. Even so, the report noted that non-US origin uranium is "likely to fill a growing portion of currently unfilled utility requirements and long-term utility purchase commitments with domestic suppliers during the second half of this decade." Mean projected values for imports range from 45 to 60 percent of domestic utility requirements throughout the 1990s, according to the report. None of the findings of the Assessment report is meant to be taken in isolation, but rather used together to form a determination of viability or non-viability. However, given the conclusions reached by the EIA report, it would have been difficult for Secretary Herrington to determine the US uranium industry to be anything other than non-viable.

* * *

The US Energy Information Administration (EIA) has released its comprehensive study of the US uranium industry, entitled "Uranium Industry Annual 1985." The study provides current statistical data on the US uranium production industry, for use by Congress and federal and state agencies, the uranium and utility industry, and the general public. The report utilizes data obtained in the EIA's annual survey of the US uranium industry. The survey was first used to collect data for calendar year 1984, and the subsequent report replaced several earlier DOE/EIA publications.

Publication of the 1985 Industry Annual came shortly after EIA released a separate study used to determine the viability of the US uranium industry. The Uranium Industry Annual, however, contains a more comprehensive review of the US uranium production sector. The principal findings of the EIA survey are summarized under two general sections — Uranium Raw Materials Activities and Uranium Marketing Activity.

Raw Materials Activities

The information contained in this section of the report ranges from US producers' efforts in exploration, development, drilling, and mine and mill production, and includes data concerning uranium resources and economic reserves. Some of the more illustrative statistics are summarized as follows.

1. US uranium production in 1985 amounted to 11.3 million pounds U_3O_8, down from 14.9 million pounds in 1984. Of the 11.3 million pounds produced in 1985, conventional milling methods yielded 6.1 million pounds. Other methods, chiefly *in*

situ leaching and by-product recovery from phosphate mining in Florida and Louisiana produced 5.2 million pounds. Although there has been some decline in production of U_3O_8 by nonconventional methods since 1981, the decline in conventional production in the last five years has been much more pronounced.

Consequently, nonconventional sources play an increasingly important role in US uranium production, amounting to 46 percent of the total.

2. The states of Wyoming, Texas, and New Mexico accounted for about 53 percent of the total domestic uranium production in 1985. In addition, approximately 80 percent of the economic reserves reported were from uranium deposits located in those three states.

3. Thirty companies reported that they participated in exploration activities in the USA, completing a total of 1.8 million feet of surface drilling. By comparison, 43 companies completed a total of 2.6 million feet of surface drilling in 1984. This typifies a decline in drilling that has been underway since 1979.

4. Total exploration and development expenditures fell to \$20.1 million in 1985, a 24-percent decline from the 1984 figure.

Marketing Activity

The information contained in this chapter of the report deals with quantities and average prices of uranium deliveries in the USA, inventories, secondary market commitments, and other marketing data.

1. The reported average contract price of uranium delivered to US utilities from domestic suppliers in 1985, including spot market contracts, was \$31.43 per pound U_3O_8, stated in year-of-delivery dollars. For 1984 deliveries, that average price was \$32.65 per pound.

2. The weighted average price for 1985 deliveries *under contracts signed in 1985* was \$15.13 per pound U_3O_8. During 1985, the Nuexco Exchange Value averaged \$15.60.

3. US utilities imported 11.7 million pounds U_3O_8 equivalent in 1985. The average price of those imports was \$20.08 per pound U_3O_8, down from an average of \$21.86 per pound in 1984.

4. The inventory level of uranium held by US utilities diminished slightly during 1985. From 160.2 million pounds U_3O_8 equivalent held at the end of 1984, the inventory level decreased to 153.8 million pounds U_3O_8 equivalent in 1985, roughly a six-year forward supply.

5. Secondary market transactions in 1985 resulted in the exchange of some 13.6 million pounds of U_3O_8 equivalent, slightly higher than the 12.3 million pounds reported for 1984.

6. Domestic suppliers reported that at the end of 1985, 237.2 million pounds of uncommitted U_3O_8 was available for sale in the 1986 to 1995 period. However, that estimate assumes unlimited prices would be available. At prices of \$40 per pound U_3O_8 or less, three-fourths of that figure, or 184.8 million pounds, were available for sale in that time period.

* * *

On Thursday, December 18, 1986, the Nuclear Regulatory Commission (NRC) suspended its general import licenses as they apply to South African and Namibian uranium, irrespective of form. Beginning January 1, 1987, importers of South African material must apply for and be granted a special NRC license before their South African material is allowed to be brought into the USA. The NRC action comes before the issuance of implementation rules by the Treasury Department, which oversees the US Customs Service, concerning the issue of whether uranium destined for reexport will be included under the South Africa sanctions bill, and whether uranium "oxides" only will be covered by the sanctions. In the event that Treasury rules to ban only uranium oxides, therefore permitting South African UF_6 to be imported, the NRC could restore its general import licenses for these products.

CORRECTION

Last month's Conversion Values Expressed in Selected Producer and Consumer Currencies (No. 220, December, 1986) mistakenly cited the ECU figure for November 30, 1985 as 4.80. This number should have been 4.07 (ECU).

© NUEXCO 1987

FOCUS

THE NUCLEAR WASTE POLICY ACT of 1982

Introduction

The Nuclear Waste Policy Act of 1982 (NWPA) addresses, within a comprehensive legal structure, serious problems of radioactive waste disposal in the USA. Nuclear power reactor by-products such as spent fuel rods and contaminated equipment are of primary concern, but the Act also deals with wastes resulting from medical and defense applications. In regard to the nuclear power industry, the Act chiefly covers disposal of high-level waste products, but also contains provisions for such aspects of nuclear policy as transportation of nuclear waste, research and development of interim storage technology, and funding of the waste plan.

Recent decisions by DOE to postpone the selection of a second repository site for high-level waste have brought the NWPA to public attention as political campaigns and congressional rhetoric focus on its implementation. During the next session of Congress, convening in January 1987, the NWPA is likely to be the subject of close examination, and substantial modification of the legislation is a possibility.

Background

Because spent fuel contains fissionable materials, the US commercial nuclear industry originally planned for the reprocessing of spent fuel elements from reactors. In the early years of commercial nuclear power, a reprocessing industry was expected to grow parallel to the growing number of commercial reactors. On that assumption, on-site spent fuel storage facilities were designed to hold only a few years worth of spent fuel elements, which typically require several years of cooling in water ponds before reprocessing can be performed. From 1967 to 1972, Nuclear Fuel Services Inc. (NFS) provided commercial reprocessing at its plant in West Valley, New York. In addition, General Electric (GE) built a reprocessing plant at Morris, Illinois, but technical problems prevented its operation. A third plant, built by Allied-General Nuclear Services (AGNS) at Barnwell, South Carolina, was completed but neither licensed nor operated.

The focus of storage and disposal of spent fuel from nuclear reactors changed considerably in the late 1970s. In April 1977, President Carter announced that commercial reprocessing of spent nuclear fuel would be postponed indefinitely. The primary reason stated for this decision was the threat of nuclear weapons proliferation from the increased handling and production of plutonium. Even though there were no commercial reprocessing facilities operating in the USA at the time of the government's announcement, the existence of reprocessing technology had enabled utilities having nuclear plants to defer long-term planning for the storage and disposal of spent fuel elements and other high-level waste materials. Moreover, the government had been able to avoid the issue of permanent disposal of highly radioactive materials.

President Carter's announcement banning reprocessing forced utilities to reconsider their options for long-term storage of spent fuel elements. Many have since modified their spent fuel storage pools to accept redesigned racks that allow denser packing of fuel elements, in some cases almost doubling storage capacity from that originally designed. However, the pool structure's inability to support the much greater weight of extra fuel elements has meant that some utilities could not make use of these redesigned racks. In some cases, spent fuel bundles have been transported to other facilities within the same utility, or to other plant sites where storage space was still available. The GE reprocessing plant has also accepted small amounts of spent fuel for storage. Nevertheless, storage capacity is approaching its limits. DOE projects that the accumulation of spent fuel will exceed 40,000 MTU by the year 2000.

The Nuclear Waste Policy Act

The Nuclear Waste Policy Act was signed into law in 1982 by President Reagan. Primary responsibility for the Act's implementation rests with DOE, but both the Nuclear Regulatory Commission (NRC) and the Environmental Protection Agency (EPA) are given interlocking roles in designing and implementing the necessary licensing and regulatory procedures. The NWPA legislation covers virtually every aspect of high-level waste disposal, including the exploration of alternate technologies for short-term storage, fee structures for utilities' contribution to a waste fund, transportation practices, and mechanisms for local government and public approval.

The rationale behind the NWPA was to ensure permanent disposal of high-level nuclear waste in a deep geologic repository. The Act calls for the federal government, under the auspices of the Department of Energy (DOE), to begin accepting spent nuclear fuel for disposal by January 31, 1998. Until that time, however, utilities must be responsible for storing their spent fuel. As part of the NWPA, an interim storage facility, the Monitored Retrievable Storage (MRS) facility, is also being considered for spent fuel and other wastes which would ultimately be contained in a permanent site.

The engineering and technical aspects involved in selecting and constructing a geologic repository are integral parts of the repository program. However, there are some fundamental political issues that must be resolved before the process of site selection and licensing can be carried out. The NWPA mandates specific ways to address these issues, which have prompted the filing of a number of lawsuits in opposition to the NWPA approach to waste disposal. In addition, the waste policy was an important issue in many state and local elections in November, especially in states closely involved with potential site selection.

The NWPA defines a process of several stages before any construction can be started. In the first stage DOE is required to:

1. Develop and issue siting guidelines.

2. Identify a number of potentially acceptable repository sites.

3. Nominate at least five sites for detailed characterization as candidate sites. Before nomination, DOE must notify the governor and state legislature in the candidate state, and must hold public hearings in the vicinity of each site.

4. Provide an environmental assessment (EA) of each nominated site.

5. Recommend to the president three of the five candidate sites for site characterization.

While this first stage is in progress, the NWPA also requires the EPA to develop and issue environmental standards applicable to a repository, and requires the NRC to develop and issue regulations for licensing a repository. After the DOE's initial selection and recommendation of three sites to the president, several steps must be taken.

1. The president must, within 60 days of receiving the secretary's recommendation, review each candidate site plan and either approve or disapprove the site, or invoke his authority to delay for not more than six months his decision to approve or disapprove. Following approval, notification is given to the governor of the affected state or to the governing body of the affected Indian tribe, if applicable.

2. After site approvals by the president, DOE proceeds with site characterization, based on detailed site characterization plans issued by DOE.

3. Following site characterization, expected to take several years, DOE prepares an Environmental Impact Statement (EIS) to comply with EPA regulations. DOE then recommends approval of one site to the president.

4. Presidential approval, if granted, then is forwarded as a recommendation to Congress. Again, the governor of the affected state or governing body of any affected Indian tribe must be notified. The state or Indian tribe may at this point submit a notice of disapproval, which can prevent use of the site unless the disapproval is overridden by a joint resolution of Congress.

After the various stages of approval are completed, final approval for construction can begin.

1. Following congressional and presidential approval, the DOE applies to the NRC for authorization to begin construction. NRC must then hold additional public hearings.

2. If the NRC grants authorization, construction may begin. After construction is complete, DOE applies to the NRC for a license to operate the repository.

Site Selection

The controversy over selection of potential sites for the primary and secondary high-level waste repositories has focused public and political awareness on the high-level waste issue. In December 1984, draft environmental assessments were issued by DOE for nine potential first repository sites in six states. DOE then recommended Hanford, Washington; Yucca Mountain, Nevada; and a site in Deaf Smith County, Texas as the three candidates for site characterization. Ranked after those were two other sites — Richton Dome in Mississippi and Davis Canyon in Utah. The three recommended sites represent a desirable diversity of rock types. The Hanford, Washington site is composed of basaltic rock; the Yucca Mountain, Nevada site is composed of volcanic tuff; and the Deaf Smith County, Texas site is a salt formation. In May, 1986, President Reagan formally approved DOE's three recommended sites, allowing DOE to begin the site characterization phase.

Since mid-summer 1986, there has been an ongoing controversy over the process and methodology used by DOE to select the sites recommended for the first repository. This controversy has also been stimulated by DOE's decision to discontinue site selection work on the second repository program. In general, site selection has become increasingly politicized, with charges being made that DOE's selection process has been greatly influenced by political concerns during the recent election, and by political maneuvering during the initial stages of the process.

Site Characterization

In the site characterization phase of the repository selection process, the NWPA requires DOE to undertake an extensive preparatory program at the three nominated and approved sites, in Washington, Nevada, and Texas. This process is expected to take at least five years and cost over $1 billion per site. Site characterization examines in detail the geologic, meteorological, geochemical, seismic, and other conditions in order to fully describe the site. On the basis of these scientific results, preliminary designs are created for a repository, and the uncertainties and limitations involving a particular site are identified.

Before actual construction can begin at a site, DOE must submit a site characterization plan to the NRC, the governor of the nominee state, the legislature of the state, the governing body of affected Indian tribes, and to the public. This plan is followed by a 3-month period for public comment and hearings. Site characterization will consist of construction of at least two exploratory shafts (based on initial drilling results) and the necessary surface and underground facilities.

At the Texas site, for example, shafts will be sunk using drill and blast techniques to between 2,600 and 3,000 feet, with subsurface facilities and ventilation tunnels extending out approximately 5,000 feet from the base of the shafts. DOE estimates that between 200 and 500 people will be employed at each site during peak site characterization activity. For sites not accepted as the permanent repository, the shafts will be filled and sealed.

Monitored Retrievable Storage

Incorporated into the NWPA is a provision for possible construction of a monitored retrievable storage (MRS) facility. Such a facility would provide interim storage (and possibly physical alteration) of spent fuel elements. As litigation and political problems delay the main thrust of the NWPA — a permanent high-level waste repository — the MRS option may become a temporary and partial solution to the high-level waste problem.

The NWPA calls for DOE to establish a federal program for siting and building an MRS facility by submitting a detailed proposal to Congress that shows site-specific designs and estimated costs of construction. This plan must include at least three alternative sites and an environmental assessment for each. In January 1986, DOE issued a proposal that identified three potential sites, all in Tennessee. The preferred site was at Oak Ridge, on the grounds of the planned Clinch River breeder reactor that was subsequently canceled.

Immediately upon DOE's issuance of the draft proposal, Tennessee filed suit in federal appeals court charging that DOE failed to properly notify the state of its siting decision. The court then issued an injunction preventing DOE from formally submitting its MRS proposal to Congress. In late November 1986, however, the appeals court ruled in favor of DOE, dissolving the injunction. Tennessee has filed for a stay of the decision pending a review by the full appeals court. Even if the Tennessee site selection is approved by Congress, however, Tennessee still has the same right of disapproval that applies to other site nominee states under the NWPA, exactly as if it were selected as a permanent repository site.

The highly publicized decision by DOE indefinitely to postpone siting work on the second permanent repository has refocused attention upon the MRS option. When presented with an MRS proposal, Congress has several options. It can approve the site as proposed by DOE; it can approve the MRS concept in lieu of an approved site; it can request selection of a different site; or it can simply take no action on the proposal.

According to a report compiled by the General Accounting Office (GAO), costs for the design, construction, operation and decommissioning of an MRS facility will probably exceed $3 billion. In political terms, the MRS seems to be assuming a larger and perhaps more acceptable role in government nuclear waste planning. Each obstacle placed in front of the permanent repository program, such as regional political struggles or lawsuits, makes the MRS a more viable intermediate option.

The Nuclear Waste Fund

The NWPA also provides a mechanism for funding part of the nuclear waste program. DOE is authorized to charge commercial reactor operators a fee of $0.001 per kilowatt hour for all electricity generated by nuclear power after April 7, 1983 (90 days after enactment of the NWPA). For electricity generated prior to the April 7 date, utilities pay a one-time fee, based on burnup and other considerations. Payment of these fees constitutes a legal contract. Under this contract the federal government agrees to take ownership of the spent fuel (and wastes derived from it) by 1998, the date specified in the Act for the completion of a repository.

To facilitate payment of the one-time fee on spent fuel generated before April 7, 1983, three options were made available to utility companies:

1. A single payment to be made by June 30, 1985.
2. Payment over 40 calendar quarters.
3. A single payment due January 1998.

In June 1985, 33 of the 47 utilities paid a total of $1.4 billion in one-time fees into the waste fund. The other 14 utilities elected to defer payment of $910 million, a sum which is expected to total $2.2 billion by 1998, including the interest due. By September 30, 1986, DOE had also collected $1.145 billion in fees for ongoing operations.

Recently, however, with extensions of several time limits written into the NWPA schedule, and the continuing legal obstructions to a repository, both utilities and the GAO have questioned DOE's ability to meet its scheduled commitment to take over the utilities' wastes by 1998. If that is the case, refunds to operators or other adjustments may have to be made to the Waste Fund.

Legal Challenges to the NWPA

From the beginning, observers have expected numerous lawsuits to be filed during the course of the NWPA's implementation. The complexity of the legislation, the large numbers of potential participants, and the increasing tendency for legislative decisions to be taken to the courts all increase the opportunities for judicial challenge to the NWPA. In addition, the nature of high-level nuclear waste creates a strong public sentiment over the location of disposal sites.

© NUEXCO 1987

The first round of lawsuits concerning the NWPA have challenged DOE's guidelines for site selection. The suits were filed in early 1985 by several states and environmental groups. A key issue has been that DOE has not properly taken into consideration NWPA requirements regarding transportation distances and proximity to waste sources. Other suits followed, claiming inadequate notification by DOE to the state of Texas of potentially acceptable sites; challenging DOE's funding of state activities concerning independent site characterization information at an early stage; charging inadequate time periods for public comment; and challenging environmental standards issued by the EPA for disposal and management of high-level radioactive wastes.

Recent Actions

On May 28, 1986, Energy Secretary Herrington announced that DOE's selection of three sites for characterization had been approved by President Reagan and that DOE was indefinitely postponing site selection work on the second geologic repository called for under the NWPA. This announcement created considerable political turmoil, particularly among authors of the NWPA and other members of Congress. Secretary Herrington stated that projections for quantities of waste materials were now considerably lower than those previously issued, and that work on a second site would be unnecessary for several years. The abandonment of the selection of a second site has been criticized as illegal and politically motivated. The NWPA contains no mechanism for the dropping of the second repository site. Rather, the Act specifically states:

"Not later than July 1, 1989, the Secretary shall nominate five sites, which shall include at least three additional sites not nominated under subparagraph (A) (the paragraph specifying the selection of the first repository), and recommend by such date to the President from such five nominated sites three candidate sites the Secretary determines suitable for site characterization for selection of the second repository." [Sec 112 (C)]

The NWPA limits the quantity of waste material in the first repository to 70,000 metric tons. The 70,000 tonne limit stipulated under the Act is purely statutory. It is not based on any scientific or technical grounds, but on estimates made in the early 1980s of high-level waste storage requirements of 65,000 metric tons by the year 2000. According to the secretary, that limit is unlikely to be reached until after the year 2020.

The selection of a site for the first repository, however, has turned into a political controversy, with positions being taken partially on the basis of an East-West division. Because the final three sites recommended to the president were all in the western half of the country — in Texas, Nevada, and Washington — while the great majority of nuclear plants are located in the East, the repository issue may further jeopardize a fragile political consensus.

Conclusion

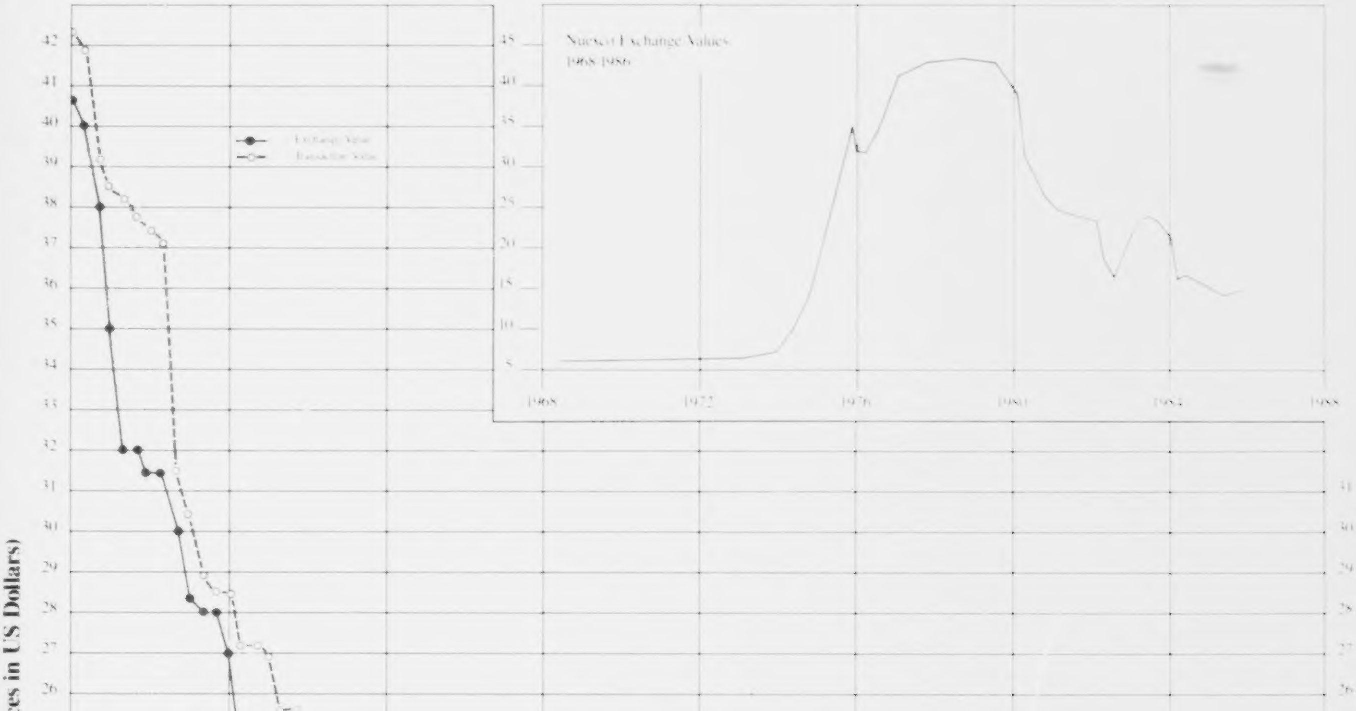
Congressional confidence in DOE's administration of the waste program has diminished over the past several years, and that situation has been aggravated by Secretary Herrington's decision to discontinue site selection work on a second repository. In addition, the prominence of the nuclear waste issue during several recent elections in states affected by the site selections has added to the ever-greater politicization of the nuclear waste issue, adversely affecting the viability of NWPA programs. There has been much discussion in Congress about reducing the discretionary authority of DOE as program administrator, and about reopening the Act to amendments.

Several vital questions concerning the future of nuclear waste policy in the USA must be addressed if the NWPA is to accomplish its objective. One such question is whether DOE is the proper agency to administer a program that has become so politically controversial as the NWPA. The issue of regional equity, particularly between east and west, certainly must be answered. There are also questions about what kind of economic incentives might be offered to states to accept a waste site.

The progress of the NWPA toward a finished site is certain to be difficult, and further delays may be inevitable, given the political conflicts and potential legal obstacles that lie ahead. But at present the Nuclear Waste Policy Act is the most significant effort to address an issue vital to the US nuclear power industry.

© NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U₃O₈)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	**16.75**

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U₃O₈)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	**17.35**

HISTORICAL CONVERSION VALUES

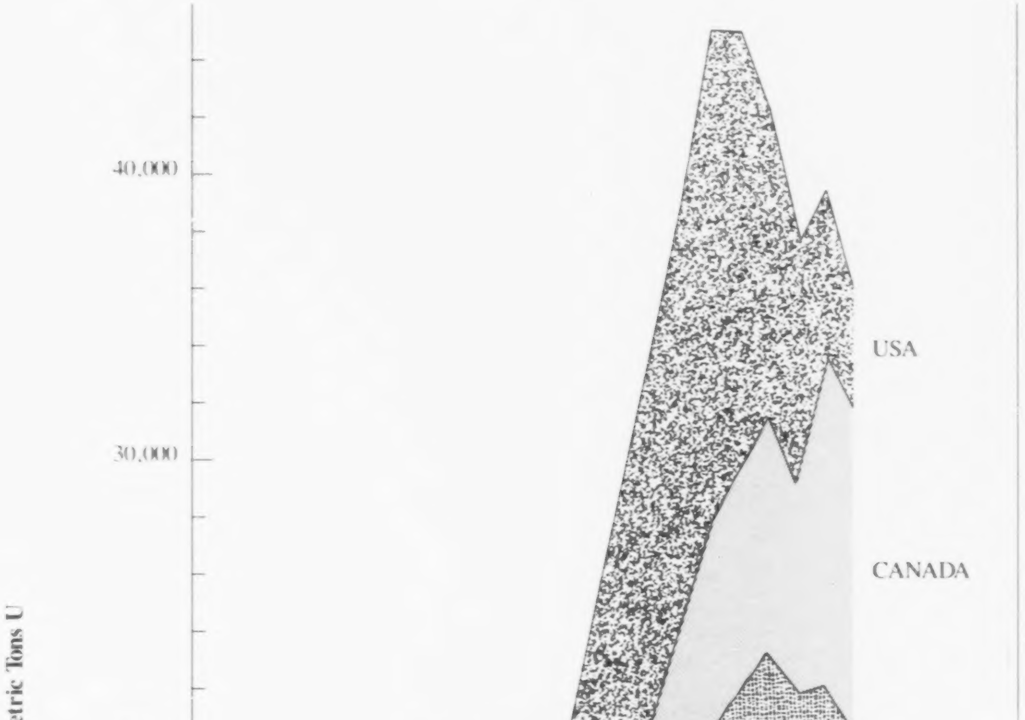
Determined as of the last day of the month indicated (US Dollars/lb. U in UF₆)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	**1.80**

© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund

© NUEXCO 1987

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

© NUEXCO 1987

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3,4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7	202.5
Oct 1985	108.4	202.4
Nov 1985	109.4	209.9
Dec 1985	110.0	210.0
Jan 1986	109.6	210.0
Feb 1986	108.7	210.0
Mar 1986	99.5	210.5
Apr 1986	94.3	210.5
May 1986	93.5	210.5
Jun 1986	95.7	210.5
Jul 1986	98.1	215.2
Aug 1986	98.2	215.2
Sep 1986	105.6	215.3
Oct 1986	—	215.4

P = Preliminary R = Revised since last month

[1] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4] Annual averages prior to 1979 reflect index base no longer in use.

[5] Monthly data for 1979-82 appear on page 35 of Report 184.

[6] Annual averages are for financial year ending June 30.

© NUEXCO 1987

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4R	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.7	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39R	16.17R	15.46R	13.31R	11.31R	12.70R
Sep 1986	119.2R	19.32P	16.54P	15.73P	13.17P	11.48P	12.86P
Oct 1986	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

---

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

© NUEXCO 1987

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140R	516,832R
Aug	1986	—	—	232.2	220.3	760,925	502,968
Sep	1986	81.94P	181.8	236.7	221.9	—	—
Oct	1986	—	—	239.3	—	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4R	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.7	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.8	297.7	330.2	115.0	13.11R	13.41R	12.03R	9.73R
Oct 1986	309.3	298.3	330.5	—	12.88P	13.88P	12.08R	9.69R
Nov 1986	309.8	298.7	330.8	—	—	—	12.13P	9.78P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

© NUEXCO 1987

INDEX TO 1986 REPORTS
Numbers 209-220

Category	Topic	Report Number	Page Number
Analysis & Commentary	Construction Backlog: Non-US Nuclear Plants	210	12
	Construction Backlog: US Nuclear Plants	211	16
	Resource Estimates	211	19
	Forecast: 1986 Uranium Production	213	13
	US Uranium Production Situation	215	23
	Enrichment Criteria: Status of DOE's Proposal	216	12
	After Chernobyl: Nuclear Power Projects In the Federal Republic of Germany	216	18
	Forecast: Nuclear Generating Capacity	217	10
	The Spot Market and the Spot Price: Applicability and Limitations	217	19
	Chernobyl Accident: Effects on Worldwide Nuclear Power Programs	219	11
	Australia's Supply Position	220	11
Annual Review	1985 Annual Review	Special Report	
	Market Developments		1
	Australia		16
	Canada		18
	Central Africa		20
	Europe		21
	Far East		42
	Southern Africa		52
	United States		56
Australia	Olympic Dam Commitment Announced	209	17
	Northern Land Council vs. ERA and Government: Legal Action Initiated	212	20
	ERA Shares May Be Acquired by Pioneer Concrete	213	14
	ERA Share Purchase Bid by Pioneer Canceled	214	15
	Labor Party National Conference Results	216	23
	Ban on Uranium Sales to France Removed	217	22
	Australia's Supply Position	220	11
Basic Considerations	Map of Nuclear Power Stations and Uranium Production Sites in the USA	215	26
	The Tails Assay Swap	218	13
	Germany's THTR 300 and the High-Temperature Reactor Program	220	14
Canada	Eagle Point: Increased Reserve Estimates	212	20
	The Rabbit Lake Project	216	25
Central Africa	Niger: FOCUS	214	11
Conversion	British Nuclear Fuels plc: FOCUS	212	4
Enrichment	DOE Incentive Pricing Offer FY1991-1995	209	2
	DOE: Recent Enrichment Developments	211	4
	Enrichment Criteria: Status of DOE's Proposal	216	12
	The Tails Assay Swap	218	13
	Enrichment Criteria: Congress Acts On Proposed Revisions	219	23

© NUEXCO 1987

INDEX

INDEX TO 1986 REPORTS
Numbers 209-220

Category	Topic	Report Number	Page Number
Essay	History of Uranium Import Limitations in the USA	215	22
	Chernobyl in Perspective	219	19
Europe	Superphenix FBR Connected to Grid	210	19
Federal Republic of Germany	After Chernobyl: Nuclear Power Projects In the Federal Republic of Germany	216	18
	Germany's THTR 300 and the High-Temperature Reactor Program	220	14
France	Total Compagnie Miniere: Restructuring Uranium Holdings	210	20
Japan	Operating Results: 1985	210	20
	Joint Uranium Mining Feasibility Study with China	210	21
	AVLIS Program: Discussions with DOE	210	21
	Annual Price Negotiations Concluded	212	20
		213	14
	Fuel Cycle Facilities in Japan	217	25
The Netherlands	Pro-Nuclear Coalition Government Retains Power	214	15
Niger	Uranium Operations: FOCUS	214	11
Raw Materials	Surficial Uranium Deposits - Part 2	209	13
	1985 US Uranium Production Activities	210	23
	The Mount Taylor Project	212	10
	Classifications of Uranium Deposits	214	20
	The Rabbit Lake Project	216	25
	Olympic Dam Project: Progress Report	218	19
	Solution Mining of Uranium, Part 1	220	20
Safeguards	NPT and AIEA Safeguards: Current Status	213	18
South Africa	1985 Production: Fourth-Quarter and Total	210	22
	1986 Production: First-Quarter Results	213	15
	1986 Production: Second-Quarter Results	216	23
	Biennial Uranium Industry Report Released by AEC	218	16
	1986 Production: Third-Quarter Results	219	22
Supply, Demand, and Pricing (Uranium)	Monthly Discussion of Pricing	all	1
	1985 Annual Review	Annual Review	1
	Exchange Rates: Effect on Uranium Prices	211	2
	The Spot Market and the Spot Price: Applicability and Limitations	217	19
	Continuing Decline of Spot Uranium Prices in European and Japanese Currencies	218	3
	World Uranium Resources	211	19
	World Uranium Production, 1980-1986	Annual Review	14
	Forecast: 1986 Uranium Production	213	13

© NUEXCO 1987

INDEX TO 1986 REPORTS
Numbers 209-220

Category	Topic	Report Number	Page Number
Switzerland	Parliament Affirms Nuclear Program	219	22
United Kingdom	British Nuclear Fuels plc: FOCUS	212	23
United States	1985 Uranium Production Activities	210	23
	Construction Backlog	211	16
	Ferret Acquires Wyoming Fuel Interest in Crow Butte	213	15
	Accounting Procedures: Proposed Revisions	214	16
	US Producers vs. DOE Lawsuit: Ruling Made	215	3
	Domenici Legislation Proposed	215	5
	Non-Viability of US Uranium Industry and Implications for US Trade Policies	215	6
	Utilities and the District Court Injunction	215	8
	History of Uranium Import Limitations in the USA	215	22
	Uranium Production Situation	215	23
	Map of Nuclear Power Stations and Uranium Production Sites in the USA	215	26
	US Uranium Producers vs. DOE Lawsuit: Recent Developments	216	2
	1986 Plant Licensing Progress	216	22
	Legislation Affecting the Nuclear Industry	217	22
	Imports of South African Uranium Prohibited	218	16
	Enrichment Criteria: Congress Acts on DOE's Proposed Revisions	219	23
	The Price-Anderson Act: FOCUS	219	25
	1985 US Uranium Industry Viability Assessment Released by EIA	220	18
USSR	Chernobyl Accident: Possible Effects	213	16
	Chernobyl Accident: Effects on Worldwide Nuclear Power Programs	219	11
	Chernobyl in Perspective: ESSAY	219	19
Index to 1985 Reports		209	24

© NUEXCO 1987

NUEXCO

REPRESENTATIVES AND CONSULTANTS

JAPAN

Kazy Yokota

Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson

Southern Prospecting (Pty) Limited
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telephone: (27-11) 838-1868
(27-11) 834-4211
Telecopy: (27-11) 834-3148
Telex: 4-89878 SA

TAIWAN

Edward Bee

Bee & Liang Company, Ltd.
14 Fl. Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg

83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

Ralph O. Smith

141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T. J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O. J. C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C. C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 221
(All data as of December 31, 1986)

Exchange Value
\$16.75, unchanged

The **Exchange Value** is **\$16.75** per pound U_3O_8, unchanged since last month.

UF_6 Value
\$47.75, down 0.25

The **UF_6 Value** is **\$47.75** per kilogram U as UF_6, down 0.25 since last month.

Transactions

One recent natural uranium sale is reported, involving **100,000 to 300,000** pounds equivalent U_3O_8. This sale involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. No transactions are reported involving natural UF_6.

Supply-Demand Ratio
decreased to 5.2:1

Active spot and near-term **uranium supply** amounts to **4.1 million** pounds U_3O_8 equivalent, down 385 thousand pounds since last month. Active spot and near-term **uranium demand** totals **800 thousand** pounds, up 30 thousand pounds. The spot and near-term **supply-demand ratio** decreased to **5.2:1.**

Transaction Value
\$17.35, up \$0.05

The **Transaction Value** is **\$17.35** per pound U_3O_8, up \$0.05 since last month. The calculation includes 14 transactions involving a total of 2.1 million pounds U_3O_8 and equivalent UF_6, and covers a period of 4 months.

Loan Rate
unchanged at 4%

The **Loan Rate** is **4 percent** per annum, unchanged. One loan transaction involving 100,000 to 300,000 pounds equivalent U_3O_8 is reported.

Conversion Value
\$1.80, unchanged

The **Conversion Value** is **\$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 750 thousand pounds U as UF_6. Active demand totals 900 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

SWU Value for
delivery within
one year: \$80, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **\$80** per SWU, unchanged since last month. No secondary market SWU transactions are reported.

* * *

Essay

Nuexco International Advisory Committee Chairman Mr. J. Robert Wolcott discusses the need for gradualism and restraint in judging South Africa.

United States

DOE Secretary Herrington has announced his finding of non-viability for the US uranium industry for calendar year 1985. In addition, the US Energy Information Administration (EIA) has released its comprehensive study of the US uranium industry, entitled "Uranium Industry Annual 1985." This article briefly examines these recent developments. Separately, the NRC has revoked all general import licenses, to be replaced with special licenses, for the import of South African uranium into the United States.

Focus

The Nuclear Waste Policy Act of 1982 has received considerable attention this year, as recent elections have focused on nuclear waste issues in general, and on site selection for a high-level nuclear waste repository mandated under the Act. This article gives an overview of the Act's provisions and examines some of the recent progress made in its implementation.

1986 Index

This Report includes an index to Reports published in 1986 (209-220).

This Executive Summary may be reproduced for internal distribution.

©NUEXCO 1987

NUEXCO

NUEXCO REPORT 221 FIGURES OF THE MONTH (December 31, 1986)	This Month (Report 221)	Last Month (Report 220)	12 Months Ago (Report 209)
Exchange Value[1]	16.75	16.75	17.00
Transaction Value[1]	17.35	17.30	16.55
UF_6 Value[2]	47.75	48.00	47.00
Loan Rate[3]	4%	4%	5%
Conversion Value[4]	1.80	1.80	1.60
Near-Term Uranium Supply[5]	4.1	4.5	3.6
Near-Term Uranium Demand[6]	0.8	0.8	2.3
Near-Term Supply-Demand Ratio	5.2	5.9	1.5
Recent Uranium Sales:			
Number of Transactions[7]	1	6	7
Quantity of Material[8]	0.1-0.3	0.8	0.9
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	459	460
3.0 w/o U_{235}	588	588	589
3.5 w/o U_{235}	719	719	720
4.0 w/o U_{235}	852	852	854

---

[1] US \$ per pound U_3O_8 equivalent.

[2] US \$ per kilogram U as UF_6.

[3] Per annum.

[4] US \$ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US \$ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US \$ per KgU as UF_6, rounded to the nearest \$.

INDEX TO LAST MONTH'S REPORT (220)

Section	Topic	Page
Analysis and Commentary	Australia's Supply Position	11
Basic Considerations	Germany's THTR 300 and the High-Temperature Reactor Program	14
United States	Domestic Uranium Mining and Milling Industry: 1985 Viability Assessment	18
Raw Materials	Solution Mining of Uranium, Part 1	20
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in November 1986	1
	Enriched Uranium and SWUs Pricing in November 1986	2

We are deeply saddened by the recent and untimely deaths of our friends and colleagues **Kim McDonald** and **Jerry Reaves**.

In December 1986, Kim Peyton McDonald succumbed to an inoperable tumor. Kim joined Nuexco in 1980 and during the ensuing six years made a great and lasting impression on all who came to know her, as well as a substantial and enduring contribution to Nuexco's success. It was her human qualities, however, that set Kim apart as someone truly unique. Her enthusiasm, warmth, infectious good humor, modesty, and caring for others were attributes seldom seen to such a degree in one person. Although her condition was first diagnosed in 1978, Kim carried on and lived her life with such joy and intensity that even her closest friends often forgot there was a problem.

Kim was 29. We shall miss her, and we join her husband, Drew, and her family and many others in honoring her life.

M. Jerry Reaves was struck and killed by an automobile on the morning of January 6, 1987 while jogging near his home in Atlanta, Georgia. Jerry was associated with Nuexco for ten years, from 1976 to mid 1986, when he established his own nuclear fuel brokerage business in Atlanta. He was part of the original team that was responsible for Nuexco's growth and success in the early years.

Jerry was a remarkable individual, a quiet, private man, whose depth of character and extraordinary professional abilities were most apparent to those who knew him well. Jerry was a listener and a thinker. When he spoke, people listened with respect. A deep love of family, loyalty to friends, integrity, and a quiet sense of humor are all attributes that caused Jerry to be admired and loved.

Jerry was 45. We join his wife, Jean, his children, Eric, Diana, and Patrick, his family and many friends in mourning the loss of this good and decent husband, father and friend.

© NUEXCO 1987

B6800-1 A
2/24/87

NUEXCO

FEBRUARY 1987
NUMBER 222

MONTHLY REPORT

ON THE NUCLEAR FUEL MARKET

NUEXCO

Three Park Central 1515 Arapahoe Street, Suite 1045 Denver, Colorado 80202

HEADQUARTERS

Chairman of the Board of Partners
Oren L. Benton

Vice Chairman of the Board of Partners
Samuel R. Freeman

Directors of Operations
Business and Financial Affairs — James E. Lewis
Administration — J. Fred Lawrence
Legal and Regulatory Affairs — Frederick J. Boyne

NUEXCO FUEL BROKERAGE SERVICES

Manager of Fuel Brokerage
Earl E. Hoellen, Jr.

BROKERAGE SERVICE LOCATIONS

UNITED STATES

DENVER
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

Managing Broker
Earl E. Hoellen, Jr.

MENLO PARK
Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

Managing Broker
George White, Jr.

EUROPE

FERNEY-VOLTAIRE
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

Managing Broker
James E. Vaughan

ZÜRICH
135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

Managing Broker
Donald P. Ebright

REGIONAL MANAGING BROKERS

AFRICA
James E. Vaughan

AUSTRALIA
George White, Jr.

FAR EAST
Earl E. Hoellen, Jr.

NORTH AND SOUTH AMERICA
Earl E. Hoellen, Jr.

(See inside back cover for list of Representatives and International Advisory Committee)

NUEXCO

KEY LAKE
A MODEL OF CANADIAN DEVELOPMENT

By

O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto, Canada

Presented to:

Deutsches Atomforum Winter Meeting

Bonn, Federal Republic of Germany
January 28, 1987

© NUEXCO 1987

NUEXCO

Three Park Central 1515 Arapahoe Street, Suite 1045 Denver, Colorado 80202

HEADQUARTERS

Chairman of the Board of Partners
Oren L. Benton

Vice Chairman of the Board of Partners
Samuel R. Freeman

Directors of Operations
Business and Financial Affairs — James E. Lewis
Administration — J. Fred Lawrence
Legal and Regulatory Affairs — Frederick J. Boyne

NUEXCO FUEL BROKERAGE SERVICES

Manager of Fuel Brokerage
Earl E. Hoellen, Jr.

BROKERAGE SERVICE LOCATIONS

UNITED STATES

DENVER
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

Managing Broker
Earl E. Hoellen, Jr.

MENLO PARK
Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

Managing Broker
George White, Jr.

EUROPE

FERNEY-VOLTAIRE
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

Managing Broker
James E. Vaughan

ZÜRICH
135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

Managing Broker
Donald P. Ebright

REGIONAL MANAGING BROKERS

AFRICA
James E. Vaughan

AUSTRALIA
George White, Jr.

FAR EAST
Earl E. Hoellen, Jr.

NORTH AND SOUTH AMERICA
Earl E. Hoellen, Jr.

NUEXCO

KEY LAKE
A MODEL OF CANADIAN DEVELOPMENT

By O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto, Canada

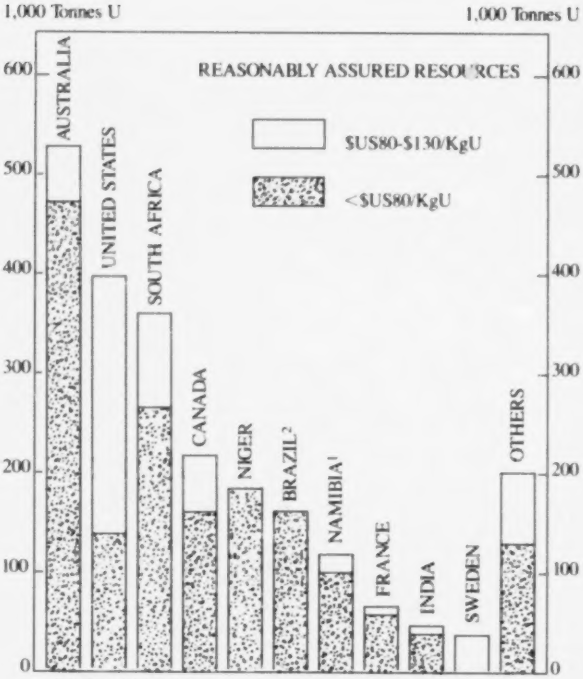
Dr. Runnalls, a resident of Toronto, Canada, worked for 20 years for Atomic Energy of Canada Ltd. until 1971, when he was appointed Senior Advisor, Uranium and Nuclear Energy in the Department of Energy, Mines and Resources in Ottawa. He also served for 5 years as Executive Vice President of Uranium Canada, Ltd. Since 1979, he has been associated with his alma mater, the University of Toronto, and is presently Chairman of the Centre for Nuclear Engineering. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

This paper was prepared and presented by Dr. Runnalls for the Deutsches Atomforum Winter Meeting at Bonn, Federal Republic of Germany, in January 1987.

Introduction

Uranium resources are widely distributed among the WOCA countries.* Recent estimates from the Nuclear Energy Agency, NEA, in Paris(1) indicate that there are 2.3 million tonnes U of Reasonably Assured Resources (see Figure 1) and 1.3 million tonnes U in the Estimated Additional Resources category. Since current requirements in WOCA countries are about 41,000 tonnes U per year, there is a comfortably large resource base to support the nuclear power industry. Coupled with this reserve there is a world-wide stock-pile of uranium which has been accumulated for at least 20 years and would provide enough fuel for existing reactors for perhaps the next three or four years (1). The majority of the resources described above by the NEA cannot, however, be exploited at today's depressed levels of approximately $US 20/lb U_3O_8 ($52/kg U). In fact, the lowest cost category outlined in the NEA report(1) is up to $80/kg U ($31/lb U_3O_8).

The most important producing countries in order of decreasing production for 1985 were Canada, South Africa, United States, Namibia, Australia, Niger and France. Collectively, these countries accounted for 96% of WOCA uranium production in 1985. The largest production came from Canada (see Figure 2). As this figure indicates, the uranium output from Canadian mines in 1985 amounted to some 30% of the total from WOCA countries. It was subdivided as outlined in Table 1.



1. OECD (NEA)/IAEA: Uranium Resources, Production and Demand, Paris, 1983, adjusted for production and estimated production.
2. In situ resources.

Figure 1. Distribution of Uranium Resources among WOCA countries(1)

From Table 1 it can be seen that 54% of the 1985 output was produced in Saskatchewan and the balance in Ontario.

The principal uranium deposits in Saskatchewan are located near the base of the Athabasca Sandstone Basin in the northern part of the province (see Figure 3). Uranium concentrations of commercial significance are usually found close to the interface of the overlying sandstone and the crystalline basement rocks beneath. Many of the deposits are unusually rich in uranium and can be recovered by open pit mining as indicated in Table 2.

Although no specific figures on reserves from Saskatchewan uranium deposits have been published recently, unofficial estimates indicate that Eagle Point is now thought to contain more than 50,000 tonnes U at a grade of about 2% U. Also, Phase II reserves at Cluff Lake have been increased about 50%. It will be apparent from Tables 1 and 2 that the Key Lake mine is one of the most important Canadian production centres. Currently it is the world's largest uranium-producing mine.

---

*WOCA, World Outside the Centrally-Planned-Economies Areas

©NUEXCO 1987

Figure 2. Approximate Share of WOCA Uranium Production, 1985

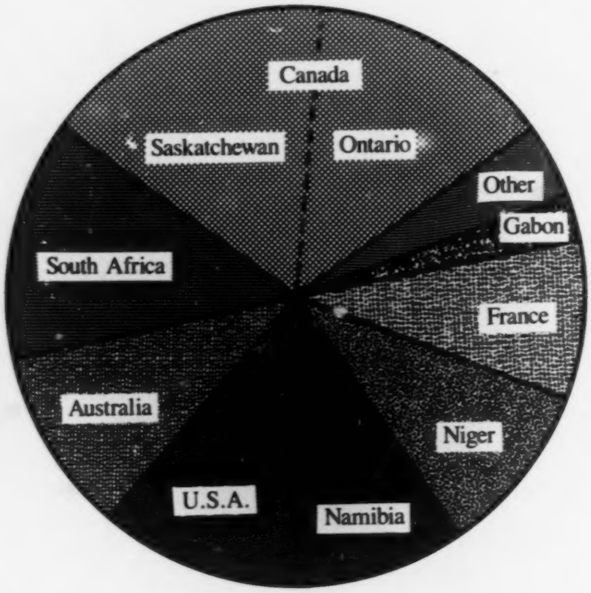


Table 1

Canadian Uranium Output, 1985[3]

Company or Mine	Location	Production, tonnes U
Key Lake Joint Venture	Saskatchewan	4,270
Cluff Mining	Saskatchewan	834
Eldorado Resources Limited (Rabbit Lake)	Saskatchewan	824
Rio Algom Limited	Ontario	
— Quirke		1,328
— Panel		827
— Stanleigh		685
Denison Mines Limited	Ontario	2,112
	Total:	10,880

Table 2

SASKATCHEWAN URANIUM DEPOSITS[5]

	Reserves, tonnes U (as of Dec. 31, 1983)	Grade, % U	Principal Mine Type
Wollaston Lake			
Rabbit Lake*	2,300	0.21	Open Pit
Collins "B"	11,500	0.38	Open Pit
Collins "D"	1,900	1.66	Open Pit
Collins "A"	6,900	9.67	Open Pit
Eagle South	6,900	0.55	Underground
Eagle Point	14,000	1.2	Underground
	43,500		
Cluff Lake			
Phase I*	400	5.9	Open Pit
Phase II	14,600	0.4	Underground/ Open Pit
	15,000		
Key Lake			
Gaertner	23,500	2.94	Open Pit
Deilmann	45,800	2.44	Open Pit
Cobble Ore	5,700	0.59	Open Pit
	75,000		

*now mined out

Key Lake Mine

The history of the development of the Key Lake mine is worth recounting briefly because the story illustrates that even in a geologically-promising area in a stable and friendly country, the lead time between launching exploration for uranium and achieving first output can be fifteen years. This is longer than the time required to bring into operation a new nuclear power facility.

After the Rabbit Lake uranium deposit had been discovered on the eastern edge of the Athabasca Basin in late 1968, there followed a major influx of uranium explorers into northern Saskatchewan. Many of these individuals were employed by companies representing off-shore interests in nuclear power from countries where uranium resources were not present in sufficient quantities to support committed and foreseen nuclear power programs.

One such company was Uranerzbergbau GmbH (UEB), of Bonn. The Managing Director of Exploration for UEB at the time was Dr. Dieter Nottmeyer, the Chairman of today's meeting. Shortly after its founding in 1968, UEB acquired an equity in two joint ventures which were exploring along the margins of the Athabasca Basin. One of these, the North Saskatchewan Uranium Joint Venture, was headed by Inexco Mining Company (Canada) Limited with 30% equity. UEB held 10%, and the remaining equity was distributed among seven other companies(6).

Little exploratory success was achieved by the joint venture in 1969 and 1970. The growing pessimism was compounded when the Canadian government announced in March 1970 that it would take steps immediately to restrict foreign ownership in new uranium-producing mines to 33% or less(7). Consequently, uranium exploration in Canada began to decline. The situation in Saskatchewan was no exception. By early 1971 only three companies remained in the group, each with an equity of 33.3%. They were Inexco, UEB and Bell Oil. Initially, Inexco continued as the operator of the joint venture.

New guidelines for exploration were evolved by the three companies based on knowledge obtained from the Rabbit Lake deposit in which Uranerz Canada Limited, a company affiliated with UEB, now had a 49% interest, and from information on the new uranium finds in the Northern Territory of Australia. The main criteria accepted by the joint venture group have been described by Gatzweiler et al(6) as follows:

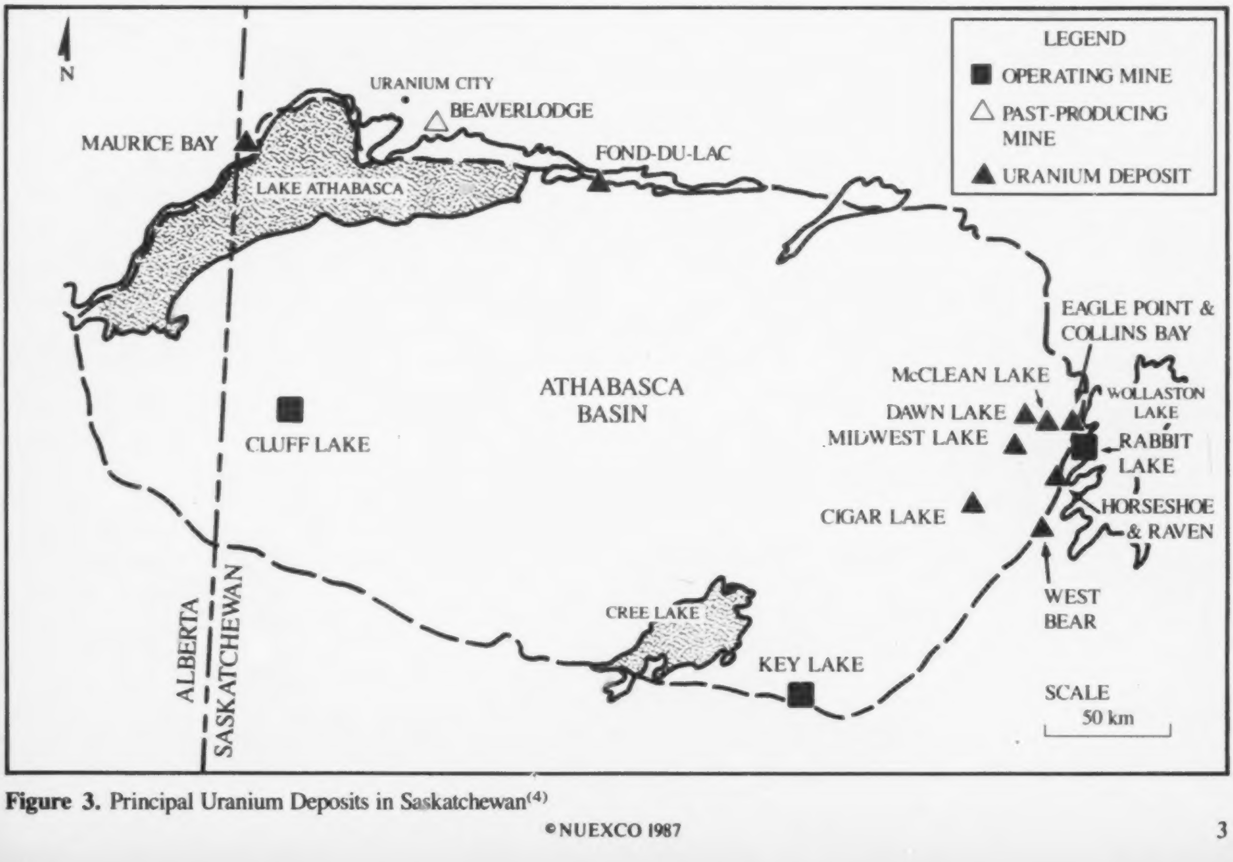

N
LEGEND
■ OPERATING MINE
△ PAST-PRODUCING MINE
▲ URANIUM DEPOSIT
URANIUM CITY
BEAVERLODGE
MAURICE BAY
FOND-DU-LAC
LAKE ATHABASCA
EAGLE POINT & COLLINS BAY
McCLEAN LAKE
WOLLASTON LAKE
ATHABASCA BASIN
DAWN LAKE
MIDWEST LAKE
RABBIT LAKE
CLUFF LAKE
CIGAR LAKE
HORSESHOE & RAVEN
WEST BEAR
CREE LAKE
KEY LAKE
ALBERTA
SASKATCHEWAN
SCALE
50 km

Figure 3. Principal Uranium Deposits in Saskatchewan(4)

1. Prospective areas had to cover the unconformity between Aphebian metasediments of the Wollaston Belt and the Athabasca formation.
2. The Aphebian metasediments had to be of shallow water deposition, including calcareous rocks.
3. The deposits searched for were fault-controlled and, more important, such faults could intersect the overlying unmetamorphosed Athabasca Sandstone. This could consequently have an effect on the erosional pattern of the sandstone margin.

Armed with these objectives, the joint venture now proceeded to work along the southeast margin of the Athabasca Basin without significant competiton.

During the summer of 1971, several radioactive swamps and two boulders rich in uranium and nickel close to the surface of the ground were found about 0.5 km northeast of Zimmer Lake and 5 km south of the Key Lake deposits yet to be discovered. Following this discovery, systematic radiometric, magnetic and electromagnetic surveys were carried out in combination with geological mapping, lake sediment and muskeg sampling. Many more radioactive boulders were discovered in the area north of Zimmer Lake in the summer of 1972. These observations prompted the initiation of a core-drilling program during the winter of 1972-73 which produced negative results.

In the meantime, an aerial photographic study had been contracted to an experienced glacial geologist. As a result, the existence of an esker was recognized, one which had ended in a delta near Zimmer Lake. This esker was typical in that it was a long, low, narrow, sinuous, steep-sided ridge composed of sand and gravel layers deposited by a stream flowing within or at the bottom of a melting glacier as it retreated(9). Further aerial photographic studies of surficial geology revealed in November 1973 a linear-shaped depression northeast of the esker which was interpreted as a "tunnel valley". A tunnel valley is thought to have been an ice-walled channel cut in the rock below the glacier. Hence, one sees now not a ridge on the surface, but rather a depression.

These observations led to the conclusion that a uranium-nickel ore body had been intersected by the tunnel valley, had been eroded, and boulders had been deposited along the path of the esker and as far away as the delta 5 km south. The tunnel valley itself passed thorugh the contemporary sites of Karl Ernst, Dieter, and Kinikinik Lakes to the edge of Key Lake. The former two lakes were named for Karl Kegel, still with UEB, and Dieter Nottmeyer. Kinikinik Lake was named by Dr. Bayrock, a consultant for UEB, and is a native Indian expression for Bearberry. The name Key Lake was picked by Dr. B. Tan, a UEB geologist. It was chosen because the first mineralized boulders were found near Zimmer Lake (or "Room" Lake when translated from the German) and the "Key" had to be found to locate the source of such boulders(9).

The delineation of the tunnel valley and the esker made it possible to decrease considerably the target area in size. Nonetheless, it was still several kilometres long, and on the basis of geochemical anomalies, more than 1 km wide. The search was rendered more difficult because there were few outcrops in the sand-covered area. To narrow down the target zone, an intensive program was mounted consisting of a ground magnetic-induced polarization/resistivity and a vertical-loop electromagnetic survey. Promising areas were then drilled. Meanwhile, as the search intensified, UEB established a Canadian subsidiary in August, 1973 named Uranerz Exploration and Mining Limited (UEM), to represent its interests as participant in and by then operator of the joint venture. Later, in 1974, Bell Oil sold its one-third interest to the Saskatchewan Mining Development Corporation, SMDC.

Finally, on July 29, 1975, spear-headed by the efforts of UEM's geologists, the discovery hole, DDH 25, was drilled. A 7-metre length of high grade uranium and nickel ore was recovered from this hole containing an average of 7.4% U_3O_8 and 4.2% Ni at a depth of about 30 metres. The deposit was named after Dr. E. Gaertner, at that time a member of the Executive Board of Rheinbraun in the Federal Republic of Germany. Rheinbraun together with Deilmann each own 50% of UEB, the parent company of UEM.

After following the main conductive zone as mapped by the vertical and horizontal loop electromagnetic survey and by applying the same drill pattern, a second ore body was discovered in June 1976. It was named appropriately the Deilmann deposit.

During the following two years, a further 2,400 holes were drilled to fully outline the location and grade of the two ore bodies. An ore boulder field south of the Gaertner deposit containing several thousand tonnes U was delineated largely by a new drilling method called sonic drilling which allowed core recovery of the unconsolidated glacial sediments(6). All told, some 75,000 tonnes U in unusually high-grade ore had been discovered (see Table 2).

Early in 1978, Inexco decided to sell its one-third interest in the Key Lake property. Saskatchewan Mining Development Corporation (SMDC), exercised its right to buy this interest by matching an offer of $US 158.5 million made earlier by Denison Mines Limited(10). As a result of arrangements between SMDC and Eldorado Nuclear Limited, one-half of the Inexco interest was subsequently acquired and retained by Eldorado, leaving SMDC with a one-half interest in the venture, UEM with one-third, and Eldorado with one-sixth through a wholly-owned subsidiary, Eldor Resources Limited.

A new entity, Key Lake Mining Corporation, KLMC, was formed in 1979 as a joint operating company to develop a mine and mill on the property. Ownership in the venture remained unchanged with participation as outlined above; viz: SMDC 50%, UEM 33.3%, Eldor Resources 16.7%. First production was achieved in October 1983. Currently, the output rate exceeds the targeted value of 4,600 tonnes U per year.

The companies involved in the Key Lake Venture represent a diverse assembly of ownership. SMDC is a Saskatchewan provincial crown corporation, UEM is privately-owned by UEB in Bonn, Federal Republic of Germany, while Eldor Resources is a subsidiary of Eldorado Nuclear Limited, a crown corporation owned by the Candian government. Although the three partners work cooperatively together in the mining and milling operation, they are competitors in the marketing of the product from the mill. Key Lake uranium has been sold by the three companies to customers in Western Europe, Eastern Asia, and the United States.

Since first production began in 1983, ore for the Key Lake mill has been obtained from the Gaertner deposit by open pit mining. In anticipation that that deposit will have been fully utilized within a few years, development of the larger Deilmann ore body is well underway. More than 2.1 million cubic metres of overburden were stripped from the deposit by year-end 1985 in preparation for mining the ore body(11). Profitable operations at a production level of 4,600 tonnes U per year are foreseen at this property until the late 1990's.

In summary, it is fair to say that the discovery and development of the Key Lake deposit is an example of the positive results that can be achieved by cooperation between governments in Canada, producing industries, and uranium customers abroad. The efforts involved were painstaking, time-consuming, and expensive, but they led to substantial rewards.

Other Canadian Developments

During 1985, the Eldor Mines Division of Eldorado Nuclear Limited completed a $100 million mine and mill development and expansion program(12). An open pit mine was developed at the Collins Bay "B" zone where an estimated 12,000 tonnes U have been delineated. This ore body will provide feed averaging 0.6% uranium to the Rabbit Lake mill which Eldorado acquired from Gulf Minerals Canada Limited and Uranerz Canada Limited in 1982, and which lies 9 km to the southwest. Rabbit Lake production capacity was expected to rise to a rate exceeding 2,000 tonnes U per year in 1986. The reserves from Collins Bay "B" are sufficient to ensure production at such volumes into the 1990's (12).

At that point Eldorado will bring into production its other wholly-owned reserves from Collins Bay "A" and "D" and from Eagle Point South containing more than 40,000 tonnes U. A further deposit containing more than 20,000 tonnes U from ore averaging 2.2% U owned jointly by Eldorado, Noranda Exploration Company, and SMDC will also be available for exploitation(12). Thus, Eldorado has discovered sufficient uranium deposits along the Collins Bay thrust and Eagle Point fault to provide a base for continuing production well into the 21st century.

In northwestern Saskatchewan, another mining operation is being conducted by Cluff Mining. Cluff is owned 80% by French-based Amok Limited and 20% by SMDC. At present the company is exploiting the "O-P" underground and "Claude" open pit mines. As the O-P deposit was depleted, production was supplemented with ore from the "Dominique-Peter" underground mine. Production from Cluff Lake in 1986 was expected to continue at about 800 tonnes U(11, 13).

In addition to northern Saskatchewan, the other principal uranium mining area in Canada is located in northern Ontario near Elliot Lake (see Figure 4).

The combined output from Rio Algom Limited's three Elliot Lake mines, Quirke, Panel and Stanleigh, is about 12,000 tonnes ore per day(14). This mining rate is adequate to provide uranium for long term sales contracts totalling some 42,000 tonnes U which extend into the 2020's. A significant development occurred in the spring of 1986 when Rio Algom and Ontario Hydro announced that they had reached agreement on a substantial modification to their long-term contract.

The milling of Denison Mines Limited 0.1% uranium ore continues at a rate of some 8,000 tonnes per day. The uranium output from this ore augmented by a 10% contribution from in-place leaching of uranium from low grade ore underground should provide adequate material to meet Denison's contractual commitments. Such commitments amount to about 56,000 tonnes U extending to the year 2012(15).

Recent information published by Energy, Mines and Resources Canada(16) indicates that total Canadian uranium resources in the measured, indicated and inferred categories recoverable from mineable ore for up to $Cdn 300 per kg U total 545,000 tonnes U, down slightly from the 551,000 tonnes U reported for 1984.

The most significant change from 1984 to 1985 was a 19% increase in measured resources largely due to continued exploration and development in northern Saskatchewan. The level of Canadian exploration expenditure in 1985, $Cdn 32 million, was some 10% more than in the previous year. Nearly 93% of the exploration costs were expended in Saskatchewan (73.4%) and in the Northwest Territories (19.4%).

The ten operators with the largest exploration budgets in 1985 listed in alphabetical order were:

Amok Limited
CEGB Exploration Canada Limited
Cigar Lake Mining Corporation
Cogema Canada Limited
Eldor Resources Limited
Minatco Limited

PNC Exploration (Canada) Limited
Saskatchewan Mining Development Corporation
Uranerz Exploration and Mining Limited
Urangesellschaft Canada Ltd.

These companies accounted in aggregate for about 97% of the total spent in 1985[16]. Two-thirds of the expenditures were made by companies based in countries abroad where indigenous uranium supplies are insufficient to meet existing and foreseen nuclear power programs.

Much of the surface development drilling in 1985 was carried out in conjunction with major programs in the Athabasca Basin in northern Saskatchewan. The most exciting prospect in the area is the Cigar Lake deposit near Waterbury Lake. The total ore reserve estimate for the deposit stands at 150,000 tonnes U[17]. This is subdivided between two regions — the main pod zone and the western extension. Reserves in the former mineralized area contain 110,000 tonnes U averaging 12% uranium. The western extension is estimated to contain inferred reserves of 40,000 tonnes U in ore averaging 4% uranium[17].

The Cigar Lake uranium deposit is flat, crescent-shaped in cross-section and has a thickness varying from 1-20 metres with an average thickness of about 7 metres. It is located at a depth of 430 metres at or near the contact between the overlying Athabasca sandstone and the underlying metamorphic gneisses.

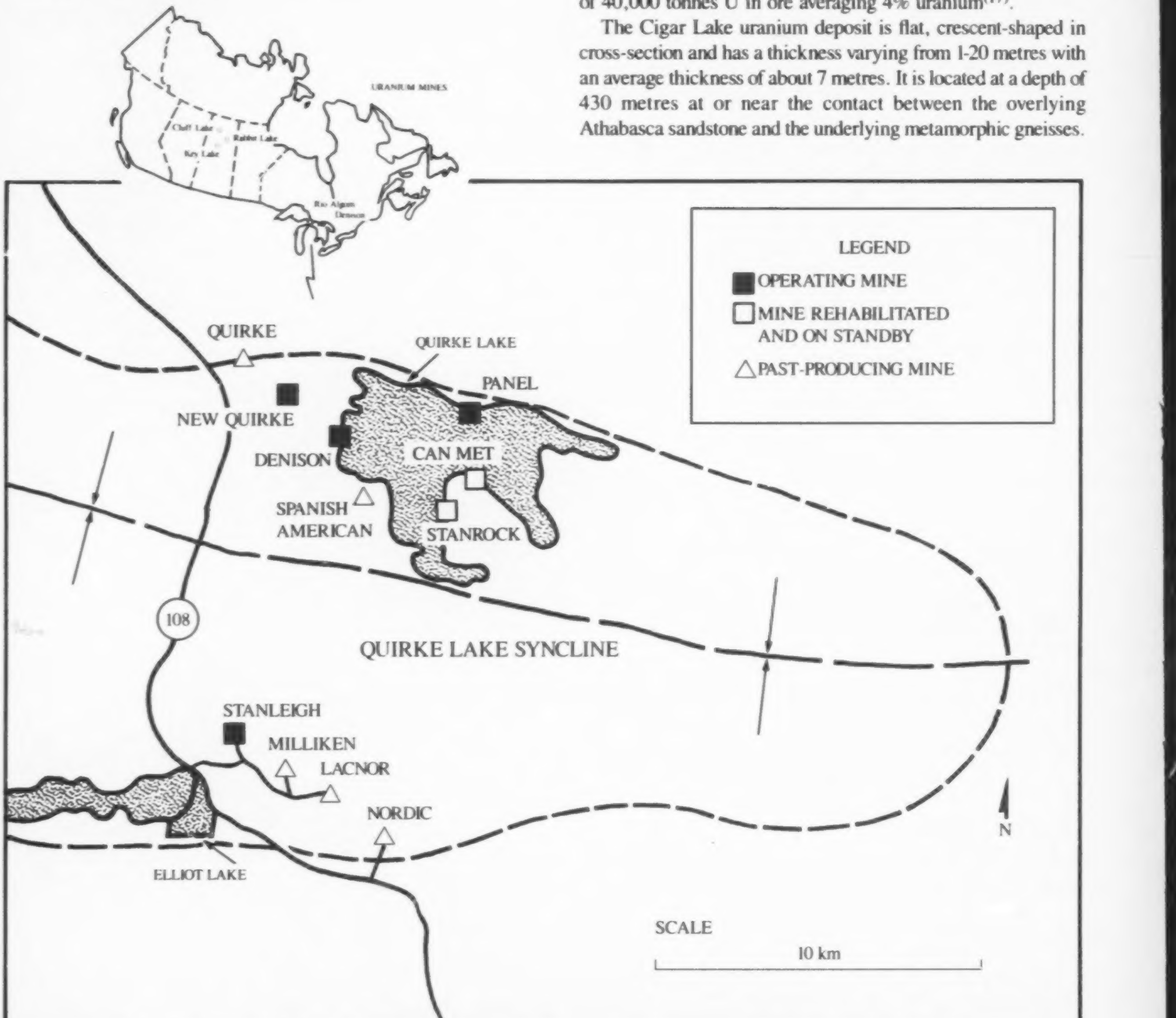

URANIUM MINES
Cluff Lake
Rabbit Lake
Key Lake
Rio Algom
Denison
LEGEND
OPERATING MINE
MINE REHABILITATED AND ON STANDBY
PAST-PRODUCING MINE
QUIRKE
QUIRKE LAKE
PANEL
NEW QUIRKE
DENISON
CAN MET
SPANISH AMERICAN
STANROCK
108
QUIRKE LAKE SYNCLINE
STANLEIGH
MILLIKEN
LACNOR
NORDIC
ELLIOT LAKE
N
SCALE
10 km

Figure 4. Elliot Lake, Ontario Producing District[4]

©NUEXCO 1987

The contacts of the mineralization with the barren rock above and below are very sharp, with the grade increasing from no measurable value to several percent uranium over a few centimetres. The mineralization is enclosed in a zone of intense hydrothermal alteration extending down to 100 metres into the basement rocks and upwards to 200 metres into the sandstone. Such far-reaching alteration zones may be associated with other uranium deposits in the Athabasca Basin adding a new powerful discovery aid for future exploration.

The rich nature of the Cigar Lake ore and the geological conditions pose particular mining problems. Nevertheless, several sophisticated mining techniques appear to be feasible and plans are underway to examine detailed mining methods with the expectation that production could commence at a rate of 4,600 tonnes U per year by 1993(17). Undoubtedly, production costs will be appreciably higher than those associated with current uranium recovery operations in Saskatchewan. The development is being carried out by a newly-formed corporation, the Cigar Lake Mining Corporation, which is owned by the following group:

Saskatchewan Mining Development Corporation (50.75%)
Cogema Canada Limited (32.625%)
Idemitsu Uranium Exploration Canada Ltd. (12.875%)
Corona Grande (wholly-owned subsidiary of Cogema) (3.75%)

Here again the ownership is a mixture of domestic goverment interests and companies from consuming countries abroad.

Several other deposits with commercial potential have been discovered in the Athabasca Sandstone region and further north in the Northwest Territories. Prospects for additional development across the country are also promising since a large number of uranium deposits have already been identified.

Domestic Requirements and Export Policy

Some of Canada's uranium is required for domestic heavy-water-moderated natural-uranium-fuelled reactors of the CANDU design. Currently, nearly 10,800 MWe of nuclear generating plants have been commissioned and another 4,300 MWe are under construction as shown in Table 4.

Canada's last major nuclear commitment, the four-unit Darlington station of Ontario Hydro, should be in service by 1992. No further nuclear stations are planned at present. Hence

Table 4

COMMERCIAL NUCLEAR UNITS IN CANADA

Station/Unit	MWe net per Reactor	Type	Operating Entity	COD	Percent Complete
NPD	22	PHWR	AECL[1]	1962	100
Pickering 1, 2	515	PHWR	OH[2]	1971	100
Pickering 3	515	PHWR	OH	1972	100
Pickering 4	515	PHWR	OH	1973	100
Bruce 1, 2	754	PHWR	OH	1977	100
Bruce 3	754	PHWR	OH	1978	100
Bruce 4	754	PHWR	OH	1979	100
Point Lepreau	635	PHWR	NBRUN[3]	1983	100
Gentilly 2	638	PHWR	HYQ[4]	1983	100
Pickering 5	516	PHWR	OH	1983	100
Pickering 6, 7	516	PHWR	OH	1984	100
Bruce 6	784	PHWR	OH	1984	100
Bruce 5	784	PHWR	OH	1985	100
Pickering 8	516	PHWR	OH	1986	100
Bruce 7	784	PHWR	OH	1986	100
Total MWe in Operation	10,787				
Bruce 8	784	PHWR	OH	1987	100
Darlington 2	881	PHWR	OH	1988	81
Darlington 1	881	PHWR	OH	1989	58
Darlington 3	881	PHWR	OH	1991	24
Darlington 4	881	PHWR	OH	1992	14
TOTAL MWe	15,095				

[1] AECL: Atomic Energy of Canada Ltd.
[2] OH: Ontario Hydro.
[3] NBRUN: New Brunswick Electric Power.
[4] HYQ: Hydro Quebec.

the current annual domestic demand of about 1,800 tonnes U will grow to some 2,100 tonnes U and will remain near that level until after the turn of the century.

During the past few years, long-term security of supply of uranium for the domestic industry has decreased in importance because growth projections for nuclear generating capacity have decreased, the uranium resource base has increased, and the domestic utilities have concluded long-term contracts with producers for future supplies. Canadian uranium production will be considerably in excess of annual domestic needs of some 2,100 tonnes U, being in the range of 11,000-12,000 tonnes U per year for at least the next decade. Thus Canada's position as a secure exporter seems assured for many years into the future.

The country's three main trading partners in terms of scheduled deliveries since 1968 and committed future deliveries continue to be the United States, East Asia and countries in Western Europe. Outstanding committed deliveries for the period 1986 through 2003 total about 63,000 tonnes U, some 12% of Canada's known resources as of December 1985 as shown in Figure 5(2). During the time period 1986 through 1990, contracts signed to date by Canadian producers will provide about 22% of WOCA requirements, as detailed in Figures 6 and 7.

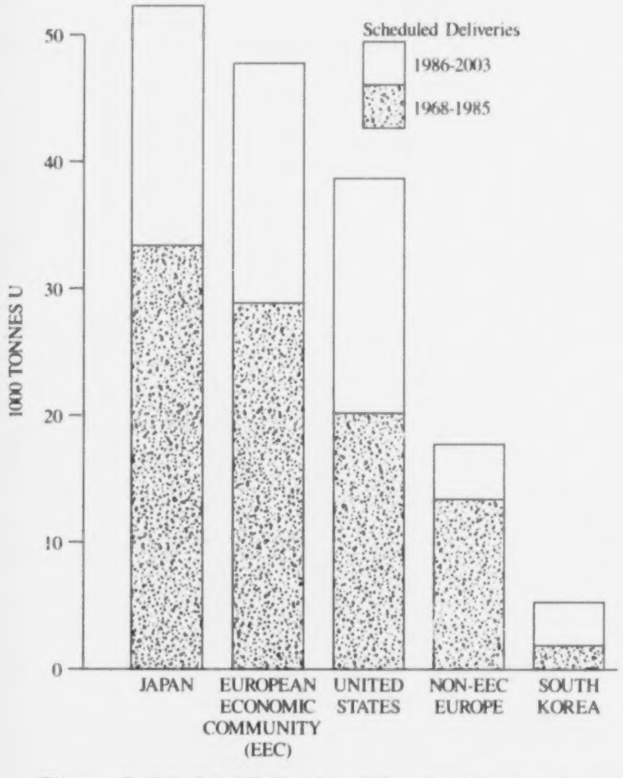


Figure 5. Scheduled Deliveries of Canadian Uranium for the Export Market(2)

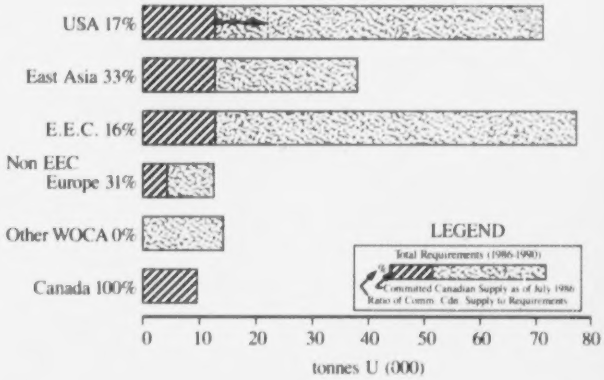


Figure 6. Uranium Requirements and Committed Canadian Supply, 1986-1990(2)

Given the firm production base, the significant number of already-found deposits yet to be developed, and the geological potential of the country, it is probable that Canada will continue to play a major role in world uranium supply for many decades into the future.

References

1. *Uranium — Resources, Production and Demand*, OECD Nuclear Energy Agency and the International Atomic Energy Agency, Paris, 1986.
2. Smith, K.L., and R.T. Whillans, *Canada's Uranium Industry-Recent Developments*, Atomic Industrial Forum Uranium Seminar, Jackson Lake, Wyoming, U.S.A., September 15, 1986.
3. Whillans, R.T., Energy, Mines and Resources Canada, personal communication, September 29, 1986.
4. *Uranium in Canada - 1984 Assessment of Supply and Requirements*, Report EP85-3, Energy, Mines and Resources Canada, September, 1985.
5. Lloyd, R.E., *Western Canada Uranium Perspective*, International Nuclear Conference, Saskatoon, Canada, June 4-6, 1984.
6. Gatzweiler, R., B. Schmeling, and B. Tan, *Exploration of the Key Lake Uranium Deposits, Saskatchewan, Canada*, Proceedings of an Advisory Group Meeting on Case Histories of Uranium Exploration, IAEA-AG-250/5, Vienna, Austria, November 26-29, 1979: 195-220.
7. *Regarding Foreign Ownership in the Canadian Uranium Industry*, Statement by the Hon. J.J. Greene, Minister of

Energy, Mines and Resources, Ottawa, Canada, March 19, 1970.
8. Kirchner, G., personal communication, August, 1985.
9. Clarke, P., *The Discovery of the Key Lake Uranium-Nickel Deposits*, Key Lake Mining Corporation Report, May 15, 1980.
10. Williams, R.M. "Uranium", *Canadian Mining Journal*, Vol. 100, No. 2, February, 1979: 143-152.
11. Saskatchewan Mining Development Corporation, Saskatoon, Saskatchewan, *Annual Report*, 1985.
12. Eldorado Nuclear Limited, Ottawa, Ontario, *Annual Report*, 1985.
13. Whillans, R.T., "Uranium", *Canadian Mining Journal*, February, 1986: 83-85.
14. Rio Algom Limited, Toronto, Ontario, *Annual Report*, 1985.
15. Denison Mines Limited, Toronto, Ontario, *Annual Report*, 1985.
16. *"Canada Continues as World's Leading Uranium Producer"*, Press Release No. 86/138, Energy, Mines and Resources Canada, September 3, 1986.
17. Peebles, G.A., and J.M. Potier, *"Mining the Cigar Lake Uranium Deposit"*, Uranium Institute Eleventh Annual Symposium, London, September 2-4, 1986.

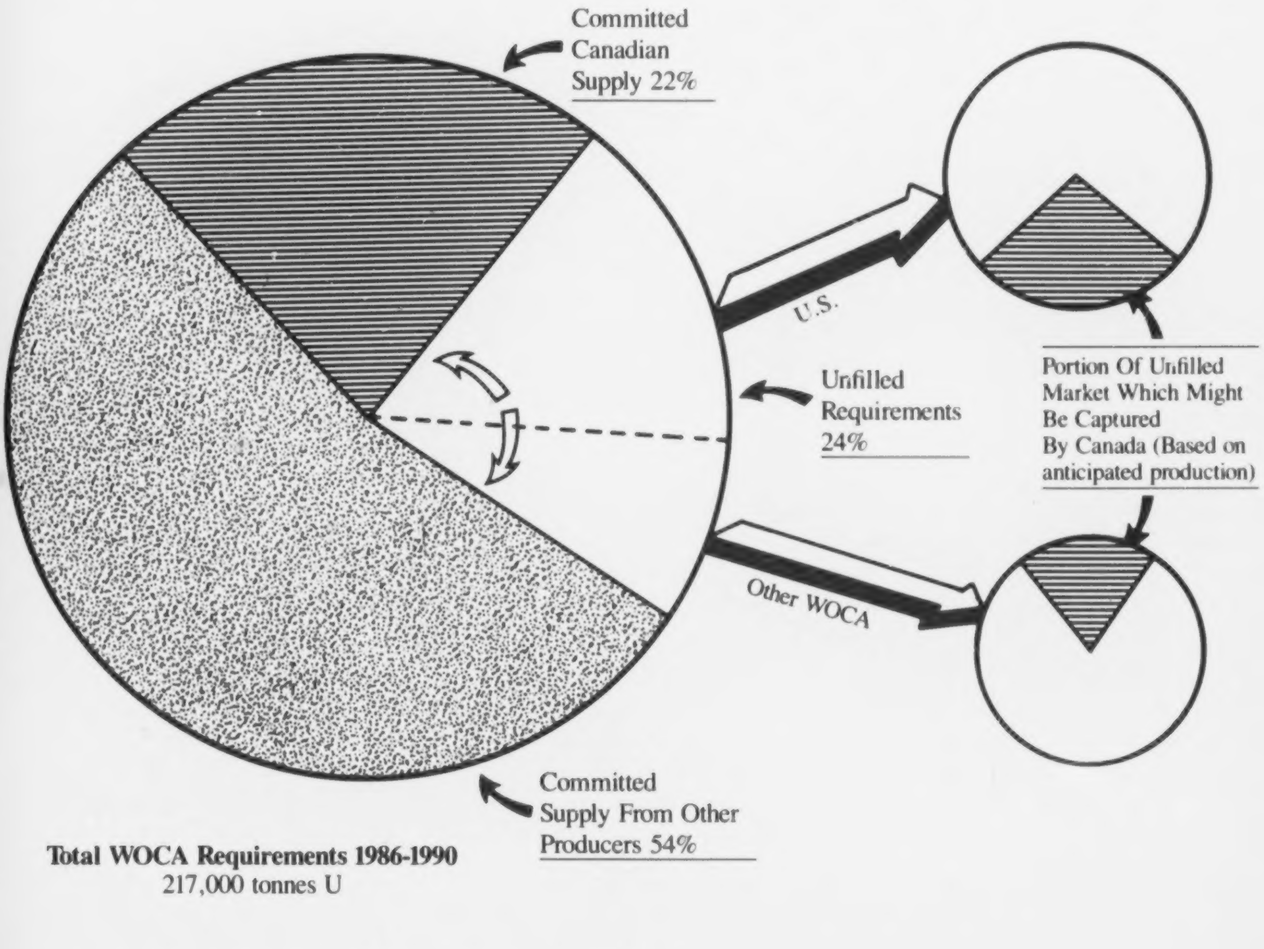


Figure 7. Canada's Share of the WOCA Uranium Market 1986-1990(2)

NUEXCO

EXECUTIVE SUMMARY
REPORT 222
(All data as of January 31, 1987)

Exchange Value **$16.65, down 0.10**	The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month.
UF_6 Value **$47.75, unchanged**	The **UF_6 Value** is **$47.75** per kilogram U as UF_6, unchanged since last month.
Transactions	**Four** recent natural uranium sales are reported, involving **100,000 to 300,000** pounds equivalent U_3O_8 in the near term, and 3,000,000 to 5,000,000 pounds equivalent U_3O_8 in the longer term. Two sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. No transactions are reported involving natural UF_6.
Supply-Demand Ratio **decreased to 1.8:1**	Active spot and near-term **uranium supply** amounts to **3.8 million** pounds U_3O_8 equivalent, down 300 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.1 million** pounds, up 1.3 million pounds from last month. The spot and near-term **supply-demand ratio** decreased to **1.8:1.**
Transaction Value **$17.35, unchanged**	The **Transaction Value** is **$17.35** per pound U_3O_8, **unchanged** since last month. The calculation includes 16 transactions involving a total of 2.4 million pounds U_3O_8 and equivalent UF_6, and covers a period of 5 months.
Loan Rate **declined to 3%**	The **Loan Rate** is **3 percent** per annum, down one percent.
Conversion Value **$1.80, unchanged**	The **Conversion Value** is **$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 330 thousand pounds U as UF_6. Active demand totals 250 thousand pounds U as UF_6. No secondary market conversion transactions are reported.
SWU Value for delivery within one year: $80, unchanged	The **SWU Value** at .3 tails and for delivery within one year is **$80** per SWU, unchanged since last month. No secondary market SWU transactions are reported.

* * *

Focus	India's national plans call for considerable growth in its nuclear industry in coming years. At present, India operates six commercial nuclear reactors, of which two are BWRs (GE) and four are heavy water reactors of the CANDU type. India's policy for nuclear development relies heavily on domestic supply of the entire nuclear fuel cycle and domestic manufacture of reactors.
Raw Materials	US uranium production in 1986 increased for the first time in five years, to approximately 13.8 million pounds, approximately 22 percent higher than 1985. This article examines US uranium industry activities state by state.
Canada	The government of British Columbia has announced that it will allow the existing seven-year moratorium on uranium exploration and mining to lapse in February 1987.
South Africa	Fourth-quarter uranium production from Chamber of Mines producers totaled 2,782,000 pounds U_3O_8, a decrease of 4.3 percent from the third-quarter. 1986 production totaled 11,563,000 pounds U_3O_8, declining 5.4 percent from 1985 figures.
United States	A Study Group composed of Atomic Industrial Forum (AIF) members has issued a report entitled *Standardization of Nuclear Plants in the U.S.*, which presents recommendations for regulatory changes, and shows cost advantages of standardization. In particular, the report recommends the issuance of Design Certifications, a new type of licensing procedure for nuclear plant and subsystem designs.
United Kingdom	The report of the Sizewell B public inquiry has finally been made public. Sir Frank Layfield, the Chief Inspector, has recommended that consent and planning permission for the plant be granted.

This Executive Summary may be reproduced for internal distribution.
© NUEXCO 1987

NUEXCO

NUEXCO REPORT 222 FIGURES OF THE MONTH (January 31, 1987)	This Month (Report 222)	Last Month (Report 221)	12 Months Ago (Report 210)
Exchange Value[1]	16.65	16.75	17.00
Transaction Value[1]	17.35	17.35	16.55
UF_6 Value[2]	47.75	47.75	47.00
Loan Rate[3]	3%	4%	5%
Conversion Value[4]	1.80	1.80	1.60
Near-Term Uranium Supply[5]	3.8	4.1	3.9
Near-Term Uranium Demand[6]	2.1	0.8	2.8
Near-Term Supply-Demand Ratio	1.8	5.2	1.4
Recent Uranium Sales:			
Number of Transactions[7]	4	1	6
Quantity of Material[8]	3.6	0.1 - 0.3	8.7
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	459	460
3.0 w/o U_{235}	588	588	589
3.5 w/o U_{235}	719	719	720
4.0 w/o U_{235}	852	852	854

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (221)

Section	Topic	Page
Essay	The South African Situation, by J.R. Wolcott	11
United States	Herrington declares US Uranium Industry Non-Viable in 1985	16
	EIA Study: Uranium Industry Annual 1985	16
Focus	The Nuclear Waste Policy Act of 1982	18
Index	Index to 1986 Monthly Reports	31
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in November 1986	1
	Enriched Uranium and SWUs Pricing in November 1986	1

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

February 1987 No. 222

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 7

RECENT DEVELOPMENTS

Canada 11
South Africa 11
United Kingdom 12
United States 13
Corrections 15

FOCUS

India's Nuclear Industry 16

RAW MATERIALS

1986 Uranium Activities 23

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 29
Historical Exchange Values and Transaction Values 30
Historical Conversion Values and UF_6 Values 31
Graph of World Uranium Production 32
US Uranium Marketing Activities Statistics 33
Volume and Price of Uranium Deliveries to the European Community ... 34

GOVERNMENT STATISTICS

Australia 35
Canada 36
South Africa 37
United States 38

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

© NUEXCO 1987

NUEXCO

To Our Readers

Nuexco is pleased to announce that Gerald Murdock has joined Concord-Nuexco International Corporation at its headquarters in Denver. Gerry was previously Vice President-Marketing at Kansas-Nebraska Natural Gas Company's subsidiary, Wyoming Fuel Company, where he had the responsibility for the marketing of coal and uranium. Prior to that, Gerry was Vice President-Sales for Mobil Coal Producing Inc. From 1969 to 1976 he was at General Electric where his responsibilities included the marketing of BWR s in the Far East. Gerry is a graduate of the Institute of Far Eastern Languages at Yale University where he studied Mandarin Chinese. He has a BS in Nuclear Engineering from the University of Tennessee and an MBA from the University of Denver.

Gerry's new responsibilities will include involvement in the increased Far East activities of Nuexco and Concord and the marketing of certain domestic new business opportunities.

* * *

Included in this Report is a slightly abridged version of a speech presented by Dr. O.J.C. Runnalls at the Deutsches Atomforum Winter Meeting, Bonn, Federal Republic of Germany, in January 1987. Dr. Runnalls is Chairman, Centre for Nuclear Engineering, and Professor of Energy Studies at the University of Toronto, Toronto, Canada. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

* * *

Nuexco will host a hospitality suite during the Atomic Industrial Forum's Fuel Cycle Conference '87 at the Westin Hotel, Copley Place, Boston, March 15-18. We look forward to seeing you there.

©NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of January 31, 1987)

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,845,000** pounds U_3O_8 equivalent, down 300 thousand pounds since last month. The corresponding figure for **active demand** is **2,143,000** pounds, up 1,343,000 pounds. The spot and near-term **supply-demand ratio** decreased to **1.8:1.**

The *Current Market Data* section of this Report lists four natural uranium concentrate sales. The two near-term transactions totaled 100,000 to 300,000 pounds U_3O_8 equivalent; the two longer term transactions totaled 3,000,000 to 5,000,000 pounds U_3O_8 equivalent. No transaction involving UF_6 is reported. US-origin natural uranium is commanding a premium of $0.85 per pound U_3O_8 (up $0.10) in the form of concentrates, and $2.50 per kilogram U (unchanged) in the form of UF_6.

The **Transaction Value** is **$17.35** per pound U_3O_8, unchanged since last month. The calculation extends over a 5-month period and includes 16 transactions involving 2.4 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, unchanged since last month. A significant price difference between what buyers are willing to pay and what sellers will accept still influences the UF_6 market.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 330 thousand pounds U as UF_6. Active demand totals 250 thousand pounds U as UF_6. No secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, down one percent.

* * *

The Exchange Value declined $0.10 this month, to $16.65 per pound U_3O_8, reflecting sellers' continued aggressive competition in response to spot and near-term sales opportunities. Substantial differences exist between prices buyers are willing to pay and those sellers are willing to accept, but sellers have been sufficiently creative and flexible in other commercial terms and conditions to make sales possible.

Amid increasing speculation that a resolution of the court case involving DOE and the US producers is imminent, the premium (relative to the Exchange Value) for US-origin concentrates has increased $0.10 since last month, to $0.85 per pound U_3O_8. Demand for Canadian-origin uranium does not appear to be especially strong; many US utilities are waiting to clarify their positions with regard to purchase of US-origin material, and European buyers generally prefer material without restrictions imposed on its end-use. An increase in demand for unrestricted uranium has made uranium of African origin more competitive in Europe; that is, it commands prices approximately on parity with other non-US material.

The large decrease in the supply/demand ratio this month was the result of a substantial increase in demand, much of which is discretionary. While such an increase in demand might be expected to cause prices to rise, competition among sellers has maintained a high level of available supply. Furthermore, discretionary buyers are highly sensitive to price and material origin, and are unwilling to raise their bid levels.

The continuing uncertainty resulting from non-resolution of the court case remains the dominant market factor, particularly in the USA. Market participants' behavior is being driven by their expectations regarding the resolution of this suit.

1. The very existence of a premium for US-origin material is a result of these expectations.
2. Market participants expect that the lawsuit will not only be resolved soon, but will be resolved in a way that is favorable to US producers.
3. Participants expect that a favorable ruling will achieve a level of import restrictions high enough to cause a direct upward movement of the price cycle.

Some buyers, due to their own special circumstances, have elected to move forward with long-term procurement, but most appear to be waiting for the court ruling before entering the market.

If the lawsuit is resolved in a way that is unfavorable to US producers (or not as favorable as expected), the premium for US-origin material may not increase as much as expected, or could even disappear. Given such a possibility, some potential buyers naturally are waiting until the lawsuit is resolved if they do not need to make purchases to fulfill current requirements. On the other hand, an Appeals Court ruling upholding Judge Carrigan's order in all respects could trigger substantial new demand for long-term supplies of US-origin uranium, resulting in upward price pressure in both the longer-term and spot markets.

* * *

The Loan Value dropped this month, to three percent. This decline reflects the general drop in interest rates. Loan transactions involving large quantities of material may potentially be concluded at lower rates than those involving smaller quantities.

©NUEXCO 1987

Because uranium inventories remain high, the emergence of any firm loan demand could be expected to result in supply being made available.

* * *

The Conversion Value was unchanged since last month at $1.80. Little activity was evident in the market for conversion services, and supply and demand both decreased since last month. No conversion transactions are reported.

* * *

ENRICHED URANIUM AND SWUS

The SWU Value is unchanged since last month, remaining at $80 per SWU. The SWU Value refers to SWU at a tails assay of 0.30 weight-percent U_{235} and for delivery within one year. No SWU transactions are reported in the *Current Market Data* section of the Report. Origin continues to be the prime consideration in determining prices paid for SWUs, although other factors, namely dates for delivery and notification, whether the SWU is contained in enriched product or is virgin SWU, payment terms, and quantities available exert an influence on prices. There continues to be a large spread of prices in the SWU market. Virgin or upgrade SWU continues to sell at a premium, while SWUs contained in enriched product sell at a discount.

One large SWU buyer entered the market this month. Although the entry into the market of buyers with small requirements may not tend to stimulate a response from potential sellers, demand for large quantities of SWUs could bring sellers into the market.

Nuexco has not reported any secondary market SWU transactions for the past two months. In fact, there has been some activity during that period in the market for near-term delivery of enrichment services, particularly in Europe. However, that activity has generally involved SWUs of Techsnabexport (Soviet) origin. Thus far Nuexco has refrained from reporting such activity because it involves sales by a primary SWU supplier and because the market for Soviet-origin SWUs is limited to a small fraction of the international market. However, the SWU market is showing an increasing tendency to blur the distinction between primary and secondary transactions, as traders and brokers become more active with primary suppliers.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

January 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.65**/lb. U_3O_8	3,845	2,143
UF_6 VALUE	**$47.75**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	330	250
SWU VALUE 0.3 tails assay; delivery within one year	**$80**/SWU		
LOAN RATE	3%/annum	0	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	17.35	2.4	16	5

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
    a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
    b. At least ten transactions;
    c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

    The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
    a. Data from recently completed transactions.
    b. Data from pending transactions.
    c. Firm bids to buy or borrow, and firm offers to sell or lend.
    d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**
Australia (dollar)	25.16	25.21	23.74	65.41	65.55	61.71
Belgium (comm. franc)	615.98	678.06	828.06	1,601	1,763	2,153
Canada (dollar)	22.33	23.16	24.14	58.05	60.20	62.75
EEC (ecu)	14.42	15.73	18.75	37.49	40.90	48.75
Finland (markka)	74.83	80.65	90.62	194.54	209.68	235.59
France (franc)	99.28	108.00	123.82	258.12	280.77	321.90
FRG (mark)	29.75	32.58	40.38	77.35	84.70	104.98
Italy (lira)	21,213	22,681	27,577	55,149	58,966	71,642
Japan (yen)	2,535	2,677	3,275	6,590	6,961	8,514
Netherlands (guilder)	33.57	36.85	45.70	87.27	95.81	118.81
South Africa (rand)	33.98	36.81	38.72	88.34	95.71	100.67
Spain (peseta)	2,122	2,219	2,548	5,517	5,768	6,625
Sweden (krona)	107.28	114.10	127.63	278.91	296.64	331.80
Switzerland (franc)	25.02	27.22	34.29	65.03	70.76	89.14
UK (pound)	10.83	11.40	12.02	28.14	29.64	31.25
US (dollar)	16.65	16.75	17.00	43.29	43.55	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**
Australia (dollar)	26.22	26.12	23.11	68.16	67.90	60.08
Belgium (comm. franc)	641.88	702.34	806.14	1,669	1,826	2,096
Canada (dollar)	23.27	23.99	23.50	60.49	62.36	61.09
EEC (ecu)	15.03	16.30	18.25	39.06	42.37	47.46
Finland (markka)	77.98	83.54	88.22	202.72	217.19	229.35
France (franc)	103.46	111.86	120.54	268.97	290.82	313.37
FRG (mark)	31.00	33.75	39.31	80.60	87.73	102.20
Italy (lira)	22,105	23,494	26,828	57,467	61,078	69,746
Japan (yen)	2,642	2,773	3,188	6,868	7,210	8,289
Netherlands (guilder)	34.98	38.17	44.49	90.94	99.24	115.66
South Africa (rand)	35.41	38.13	37.70	92.05	99.13	98.01
Spain (peseta)	2,211	2,298	2,481	5,749	5,974	6,450
Sweden (krona)	111.79	118.19	124.25	290.63	307.26	323.02
Switzerland (franc)	26.07	28.19	33.38	67.77	73.30	86.78
UK (pound)	11.28	11.81	11.70	29.33	30.71	30.42
US (dollar)	17.35	17.35	16.55	45.11	45.11	43.03

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Jan. 30, 1987.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**	**This Month (Jan 31, 1987)**	**Last Month (Dec 31, 1986)**	**12 Months Ago (Jan 31, 1986)**
Australia (dollar)	2.72	2.71	2.23	6.00	5.97	4.93
Belgium (comm. franc)	66.59	72.87	77.93	146.81	160.64	171.82
Canada (dollar)	2.41	2.49	2.27	5.32	5.49	5.01
EEC (ecu)	1.56	1.69	1.76	3.44	3.73	3.89
Finland (markka)	8.09	8.67	8.53	17.83	19.11	18.80
France (franc)	10.73	11.61	11.65	23.66	25.59	25.69
FRG (mark)	3.22	3.50	3.80	7.09	7.72	8.38
Italy (lira)	2,293	2,437	2,594	5,056	5,373	5,718
Japan (yen)	274.06	287.72	308.23	604.19	634.32	679.52
Netherlands (guilder)	3.63	3.96	4.30	8.00	8.73	9.48
South Africa (rand)	3.67	3.96	3.64	8.10	8.72	8.04
Spain (peseta)	229.42	238.41	239.84	505.78	525.60	528.77
Sweden (krona)	11.60	12.26	12.01	25.57	27.03	26.48
Switzerland (franc)	2.70	2.93	3.23	5.96	6.45	7.11
UK (pound)	1.17	1.23	1.13	2.58	2.70	2.49
US (dollar)	1.80	1.80	1.60	3.97	3.97	3.53

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Jan 31, 1987)**	**UF_6 Value per kg.U in UF_6 This Month (Jan 31, 1987)**	**UF_6 Value per kg.U in UF_6 Last Month (Dec 31, 1986)**
Australia (dollar)	120.88	72.15	71.88
Belgium (comm. franc)	2,960	1,767	1,933
Canada (dollar)	107.28	64.03	66.01
EEC (ecu)	69.28	41.35	44.85
Finland (markka)	359.55	214.60	229.92
France (franc)	477.04	284.73	307.86
FRG (mark)	142.96	85.32	92.87
Italy (lira)	101,924	60,836	64,658
Japan (yen)	12,180	7,270	7,633
Netherlands (guilder)	161.29	96.27	105.06
South Africa (rand)	163.27	97.44	104.94
Spain (peseta)	10,196	6,086	6,325
Sweden (krona)	515.46	307.66	325.27
Switzerland (franc)	120.19	71.73	77.59
UK (pound)	52.02	31.04	32.50
US (dollar)	80.00	47.75	47.75

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Jan. 30, 1987.

©NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3934	1987	101-300	105	Producer	Utility	US origin.
3931	1988-1998	1,501-3,000	See remarks	Producer	Utility	Base price escalated. US origin.
3914	1987	50-100	100	Producer	Utility	
3913	1990-1995	301-600	R[5]	Producer	Utility	US origin.

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.

[3] Price is not normalized to 0.20% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

URANIUM SUPPLY
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335	400	—	
2740	100	—	
2885B	230	—	UF_6
2893A	480	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2975	250	—	
2989	40	—	
2990	130	—	UF_6
3023	500	500	UF_6
3121	500	—	
3127*	100	—	
3129	500	500	
3194*	100	—	
2263	—	400 per year	1988 on
2781	—	750 per year	1988-95
2981	—	600 per year	1988-91
2996	—	500 per year	1988-90
3171	—	200 per year	1988-92
TOTAL:	3,845		
INACTIVE			
2297*	100	100 per year	1988-89
2389	75	75 per year	1988-90
2764	260	—	UF_6
3128	100	—	
3166*	25	—	
3168*	50	100 per year	1988-92
2336*	—	100 per year	1988-94
2625	—	500 per year	1988 on
TOTAL:	610		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: None.

© NUEXCO 1987

CURRENT MARKET DATA

URANIUM DEMAND
(January 31, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Inquiries to Purchase:			
ACTIVE			
2878B	30	—	UF_6
2890*	350	—	
2956	350	350	U_3O_8 or UF_6
2984*	170	—	
2991	105	—	UF_6
2995*	260	—	
3009*	590	—	UF_6
3017*	230	—	
3158*	8	—	UF_6
3192*	50	—	
2738	—	1,000	1989 on
2962	—	500	1989 on
2985	—	675 per year	1992 on
3097	—	300 per year	1988 on
3147*	—	200	1989-92
TOTAL:	2,143		
INACTIVE			
2760	750	750 per year	1988-90
2798	70	—	
2936	—	400 per year	1988-95
TOTAL:	820		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2948, 2977, 3075.

©NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF$_6$) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
3165*	330	—	
TOTAL:	330		
Available for Sale: INACTIVE			
2859*	750	750	
2988	165	—	
TOTAL:	915		
Inquiries to Purchase: ACTIVE			
2949	250	—	
TOTAL:	250		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997*	650	—	
TOTAL:	1,050		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2920	2,000	—	
TOTAL:	4,500		

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 2861.

No inquiries to borrow are reported this month.

SWU SUPPLY AND DEMAND
(January 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2969*	200	—	1987
3156	70	—	1987
TOTAL:	270		
INACTIVE			
2571*	55	—	1987
TOTAL:	55		
Inquiries to Purchase:			
ACTIVE			
2878	65	—	1987
2999	150	—	
3009*	200	—	
3043*	15	—	1987
TOTAL:	430		

*New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2879, 2985, 2987, 3015.

©NUEXCO 1987

CANADA

British Columbia's newly-elected Social Credit government is expected to allow the province's seven-year moratorium on uranium exploration to lapse February 28, 1987. The announcement by the Ministry of Energy, Mines and Petroleum Resources deliberately downplayed BC's uranium resources, calling them "relatively small and low in grade," possibly to lessen any potential reaction from anti-nuclear voters.

Most affected by the termination of the moratorium are the owners of the Blizzard deposit, near Kelowna in south-central British Columbia. This deposit is held by Lacana Mining Corporation with three partners: Ontario Hydro; Norcen Energy Resources Ltd. (the operator); and Campbell Resources Inc. Drilling has indicated reserves of approximately ten million pounds U_3O_8, at an average grade of 0.21 percent uranium. The deposit is considered mineable by open-pit methods. Prior to the declaration of the moratorium, owners of the Blizzard property had signed a long-term supply contract with Korea Electric Company, even though no uranium had yet been produced from the property.

Although Kelowna is a well known tourist area, with established environmental criteria for mining operations, other mines have successfuly operated in the area for many years. In particular a large, open-pit copper mine is in operation nearby, and the neighboring Highland Valley, which contains an existing copper-molybdenum mining district, is a good source of skilled labor for mining projects.

SOUTH AFRICA

Fourth-quarter uranium production from Chamber of Mines producers totaled approximately 2,782,000 pounds U_3O_8, a decrease of 4.3 percent from the third quarter figure. Table 1 shows the quarterly and total production figures from 1986.

Total production for 1986 was 11,563,000 pounds U_3O_8, a decline of 5.4 percent from the 1985 level of 12,218,000 pounds, and over twenty percent below 1984 production of 14.5 million pounds. Some of the factors which contributed to the 1986 production results include the following:

1. Buffelsfontein production declined 257,000 pounds (16.3 percent) because of mining difficulties in the Strathmore shaft area, resulting from the unexpected complexity of the geologic structure.

2. Harmony Gold Mining Company Ltd. closed its Virginia plant at the end of August 1986 because of declining uranium demand and low prices as well as the lower grade ore being mined, resulting in a production decrease of over 212,000 pounds (22.6 percent).

3. Production at Chemwes (Stilfontein) increased by 7.2

Table 1

REPUBLIC OF SOUTH AFRICA:
1986 URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	First Quarter 1986	Second Quarter 1986	Third Quarter 1986	Fourth Quarter 1986	Total 1986
Buffelsfontein	353	300	362	302	1,316
Driefontein Consolidated	41	49	46	43	180
ERGO[2]	91	88	79	86	343
Harmony	231	211	171	116	728
Hartebeestfontein	238	264	267	257	1,025
JMS[3]	318	305	279	266	1,168
Randfontein	339	324	304	356	1,324
Stilfontein (Chemwes)	137	135	141	226	638
Vaal Reefs	1,082	1,069	1,107	997	4,255
Western Areas	155	147	150	133	585
TOTAL[4]	2,983	2,892	2,906	2,782	11,563

[1] Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.

[2] ERGO = East Rand Gold and Uranium Company Ltd.

[3] JMS = Free State Joint Metallurgical Scheme.

[4] Columns may not add due to rounding.

© NUEXCO 1987

percent overall, including an increase of nearly 60 percent since the third quarter.

4. Production at Vaal Reefs and Hartebeestfontein decreased by 9.9 and 3.7 percent respectively during the fourth-quarter, but recorded slightly increased totals over 1985 figures.

Because South Africa's uranium industry is so heavily based on by-product production from gold mining, the continuation of difficult market conditions during 1986 affected uranium output less than might have been the case otherwise. Gold prices were very high in rand terms; the weakness of the rand against the dollar also accounted for record uranium prices in rand terms, because South Africa's uranium contracts are priced mainly in dollars.

UNITED KINGDOM

The long-awaited results from the Sizewell B public inquiry were released in late January. Sir Frank Layfield, the Chief Inspector who conducted the inquiry, issued a report recommending that "planning permission for a PWR power station, Sizewell B, should be granted..." Layfield based this judgment on a number of conclusions, including the following.

1. CEGB showed that building the proposed PWR is likely to save generating costs and provide a baseload station to meet future capacity needs. A new generating station will be required in the near future, and the PWR is likely to be the least-cost means of meeting the requirement.

2. Layfield determined that there is "national interest in building a PWR," and anticipated economic benefits in doing so. Achieving cost-saving electricity generation, meeting rising capacity needs, and reducing CEGB's reliance on one principal fuel all contribute to the national interest.

3. The proposed Sizewell site for the station was determined to be suitable, meeting all of the necessary technical requirements for a large generating station.

The Sizewell inquiry began in January 1982 and the Energy Secretary initiated preliminary hearings that year. Public hearings began in Suffolk in January 1983. The inquiry was intended to give the public the opportunity to discuss all of the issues surrounding nuclear power in the UK, and in particular to examine an analysis of the need, economics, safety concerns, waste management, and environmental impact of the Sizewell plant. The inquiry covered all of those areas, but it also encompassed much more as the hearings stretched far beyond the original schedule

The Central Electricity Generating Board (CEGB) assumed the responsibility of arguing the case. The arguments heard included the following.

1. Critics claimed that CEGB's overcapacity was nearly 30 percent, demonstrating little near-term need for the planned unit, and that given the prevailing schedule for the plant's completion, Sizewell would be operational several years before demand increased. CEGB on the other hand, has long argued that the considerable length of time required for construction would mean that the proposed unit would be ready just in time for a projected increase in new capacity requirements of 10,000 MWe by the year 2000, when several older plants will be approaching the end of their operating lives. Recently, in fact, CEGB needed to shed some 2,000 MW of peak electrical load by means of frequency reduction (to 49 Hz), even though it was importing power from Scotland and France at the time.

2. Advocates of nuclear power cited the advantages of reducing the nation's dependency on coal. The Sizewell unit, and the PWR program in general, could greatly advance the diversification of electricity sources.

3. While CEGB asserted that the PWR would produce electricity for consumers at lower cost than either a new AGR unit or a coal-fired plant, critics claimed that future coal costs might not be as high as predicted, and unforeseen delays and construction cost overruns could erase the PWR's cost advantage.

Over time, the inquiry evolved into a general debate over nuclear power in the United Kingdom. The considerable progress made in the implementation of the Advanced Gas-cooled Reactor (AGR) undoubtedly influenced the inquiry to some degree; six AGR units entered commercial operation between 1984 and 1985. There also was concern over the UK's lack of indigenous PWR operating experience. Although no PWRs have been built in the UK, there is no shortage of technical expertise or operating experience available from other countries, notably France and the USA. Some critics, however, questioned whether a PWR is the right choice of reactor, pointing to the development of "inherently safe" reactors, underway in Sweden and the Federal Republic of Germany. Contracts for the Sizewell unit have been given to Framatome for the reactor vessel, and to Westinghouse for design work and primary circuits. Much of the work is intended for subcontracting to suppliers in the U.K.

The expanding inquiry delayed construction on the PWR, which was originally scheduled to begin in 1982. Ironically, during the period of the inquiry delays in construction actually helped CEGB's financial situation by saving money needed to import fuel oil during the nation's 1984-85 coal miners' strike, and by deferring dollar payments on Sizewell contracts while the value of the pound sterling gained against the dollar. The public inquiry ended in February 1985, more than two years after it had begun, when final evidence was presented to the Inspector. Now that the conclusions of the Sizewell Inspector have been issued, the report will be studied by the government and debated in Parliament, so it is possible that formal approval for Sizewell will be granted before mid-1987. As of mid-1986, CEGB had invested heavily in the project, and is in advanced stages of design work on most of the plant.

UNITED STATES

In late 1986, the Study Group on the Practical Application of Standardized Nuclear Power Plants in the United States released a report entitled *Standardization of Nuclear Power Plants in the U.S.* The report was the product of a year-long effort by a group composed of members of the Atomic Industrial Forum (AIF), a non-profit nuclear industry membership group in the USA. The purpose of the study was to "define the actions needed for the effective implementation of standardization, and to determine the practical benefits of standardization, mainly with regard to safety, operations and cost." The report examined how plant standardization could affect the regulatory process, recommended changes, and discussed how standardization might affect the cost of nuclear power.

The Regulatory Process

On March 20, 1986 the study group sent its position paper on standardization to the Nuclear Regulatory Commission (NRC), recommending a number of proposed changes in the regulatory process. The main change involved the NRC allowing a new type of licensing procedure, called Design Certification (DC). Under the proposed procedure, once a hypothetical standardized design is granted the certification, individual licensing hearings could not challenge the validity of the approved design. Applications for the proposed DCs would require extremely detailed design information, necessitating that a nearly complete design be presented to get such a license. Upon completion of licensing, a utility should realistically be able to schedule construction around a well defined plan, thereby greatly decreasing the risk inherent in a schedule that could be interrupted for long periods by licensing or regulatory delays. In essence, using preapproved standard designs would allow one-step licensing, in contrast to the many steps now required.

A "standardized design" could be a complete nuclear plant design, a nuclear steam supply system (NSSS), the balance of plant, or any reproducible discrete subsystem that could be standardized across a variety of locations, and which could be licensed by the NRC. The owner could use those whole plant or subsystem designs to apply for construction and operating licenses. The modular nature of the process would allow greater accuracy in cost projections and reduce the uncertainties of the licensing process.

The report argued that today's nuclear licensing process is needlessly complicated. A typical plant undergoes a licensing sequence as follows:

1. Application is made for a construction permit, presenting preliminary design information.
2. NRC staff review is followed by a public hearing.
3. Plant design is finalized simultaneously as construction proceeds.
4. The utility submits its application for an operating license to the NRC.
5. The NRC technical staff reviews the application; it considers the final design and construction, equipment testing, quality control, proposed operating procedures, and changes made according to regulatory requirements enacted since the construction permit was issued. A public hearing may follow.

After the review and public hearing, design changes, more inspections and reviews, and other delays frequently occur. In the report, the study group argued that the uncertainty and instability of such a process negatively affects utilities, engineers and designers, and the public. Standardization must revolve around the security of Design Certifications, which, once approved, would not be accessible to further challenge.

The report listed several key changes that would contribute to greater acceptance of standardization and preapproval of designs.

1. The NRC should review and approve applications for standard designs even without a reference application.
2. The NRC should refrain from additional review of approved designs, unless it determines that the design fails to assure adequate levels of public health and safety, defense and security, based on new information.
3. The NRC should assign a senior manager to oversee implementation of its standardization policy.
4. The NRC should modify its regulations to ensure that once a reference application has been given approval to begin construction using a standardized design, no further changes could be required, lacking a good cause.

In addition, the study group recommended eliminating the present limitation of 10 units that applies to the number of plants that can be built under a manufacturing license, and increasing to ten years the duration of standard design approvals.

The report recommended a concept called a "reference system." This is a departure from the current licensing process, although retaining some of the existing procedures. An application for a reference design could exist independently of a construction permit or a construction and operating license, but could, if desired, follow established procedures for obtaining a Preliminary Design Approval (PDA) or Final Design Approval (FDA). Using the existing NRC procedures could help a designer by allowing NRC review at a stage when changes are more easily made, and by gaining NRC staff concurrence regarding design characteristics. PDA applications would contain a level of design information approximately equivalent to that required for current construction permit applications. The

©NUEXCO 1987

more complete applications for Final Design Approval would not need to be proceeded by a PDA, and could be referenced in applications for a Design Certification. The study group's position paper recommended that FDAs be made effective for 10 years, as well as allowing requests for renewals.

Design Certifications are not currently issued by the NRC. In making DCs the cornerstone of standardization, the study group recommended that DCs not *require* prior PDA or FDA applications, although they may go through that procedure if desired. DCs should be effective for ten years, renewable by the NRC for no less than five, nor longer than ten years. A highly detailed design necessarily must be part of the DC process, approximating the level necessary to obtain specific equipment in construction bids. Once a DC was issued, challenges to the design could take place only in a DC amendment proceeding. Third parties would be able to challenge the design only if significant new information indicated that the design failed to ensure adequate protection.

Effect of Standardization on Costs

The study group's analysis of costs found that significant cost savings could be expected in both direct and indirect cost categories and in time-related costs, with the greatest savings in time-related costs. The report compares a "Best Cost Experience Plant" to a model plant built using standardized designs, both using a 1,200 MWe plant model authorized in 1986. The best cost experience plant is based on the Energy Economic Data Base and uses actual cost experience. Against this model, the analysis compares a hypothetical plant built as one in a standardized series (called an nth plant), which is partly determined from data available from standardized nuclear construction programs in other countries. In both models, the major cost components are analyzed in detail. The construction periods expected under the best-cost plant and the standardized plant model are eleven and six years, respectively.

Direct and indirect costs mainly covered such items as equipment and material, construction costs, design and management services, and owner's costs. According to the study, the standardized plant model showed overall cost savings of between 24 and 38 percent in the direct and indirect costs category. The most significant savings would be achieved in design and management services, which could be reduced by 66 to 72 percent compared to the best-cost model plant. These savings would be gained through sharing costs and utilizing the same reference designs among multiple facilities. The study showed construction cost reductions of between 10 and 20 percent; equipment and material cost savings of 5 to 10 percent; and savings in training manuals and technical operation specifications and procedures of 3 to 5 percent.

Cost savings that might be achieved by standardization were even more significant in the category of time-related costs, in particular escalation and financing. The projected shortening of the construction schedule, from eleven years under the best-cost model to six years under the standardized model, mainly accounted for the potential savings of approximately 75 percent. According to the data base used in the best-cost model, 61 percent of the capital costs of an average light-water reactor entering commercial operation between 1985-88 were time-related; a potential savings of 82 percent in costs of escalation and financing could be realized using the standardized plant model. In terms of overall cost savings, a standardized nuclear plant authorized in 1986 and scheduled for commercial operation in 1992 potentially could be built for 55 percent less than a model "best cost experience" plant. Such a standardized plant could be built for $1,186 per kilowatt, versus $2,650 for the best-cost model plant.

UNITED STATES

The future of the Atomic Vapor Laser Isotope Separation (AVLIS) program, the Department of Energy's laser enrichment research effort based at the Lawrence Livermore National Laboratory (LLNL), appears to be rather uncertain at this time. The Reagan administration's proposed FY 1988 budget request to Congress contains no funds to continue the program, although there is much doubt about whether the program will actually cease. The possibility exists that Congress could reinstate funding for the program, even without a specific budget request. In other to achieve zero spending by 1988, DOE must close the program during 1987, therefore it has requested that its FY 1987 budget be revised to terminate the AVLIS program.

The administration's June 1985 decision to stop development of the Gas Centrifuge Enrichment Program depended to some extent on continued progress of the AVLIS program; therefore the recent action raises questions about the direction of the DOE enrichment enterprise. The decision to cut funding could be a signal by the administration that it intends to proceed with privatization of the enrichment business as quickly as possible, or even that, while appearing to cut costs, it expects Congress to reinstate the program's budget. There is precedent for such action by Congress; when the administration cuts AVLIS funding in its FY 1987 budget request, Congress added $30 million to the program to raise the budget back to the $80 million level thought by Congress to be adequate.

The logic behind the action seems to be that elimination of costs incurred by the AVLIS program will make DOE more competitive in the short-term; disadvantages in long-term outlook would, under the assumption of some degree of privatization, largely be inherited by private industry. There remains the question of whether Congress will permit the administration and

©NUEXCO 1987

DOE to take a short-sighted view of the USA's future participation in the international enrichment business. The investment in development of AVLIS has given the USA a significant lead in this technology, a lead that will be surrendered to the French, whose research and development in laser enrichment technology is reportedly not far behind, if the program is terminated.

The decision to drop the AVLIS program from the proposed budget is closely tied to the issue of future privatization of enrichment services in the USA. Up to now, the government has made no firm commitment either to allow or not allow enrichment on a private basis. Potential investors are, therefore, justifiably wary of committing themselves to further research and development of the AVLIS technology, particularly as DOE already conducts similar research under the Strategic Defense Initiative (SDI), also at Lawrence Livermore National Laboratory. Lacking an unequivocal position by the Congress and the Reagan administration on privatization, it seems likely that Congress will fund continued AVLIS development.

* * *

CORRECTIONS

Last month's Report (#221, January 1987) contained the following errors.

On page one, the Report stated "conversion supply has declined and supply has increased." This should have read "conversion supply has declined and *demand* has increased."

Also, the headings for the tables on pages 25 and 26 were reversed. *US Uranium Marketing Statistics* should have identified the table on page 26, while *Volume and Price of Uranium Deliveries to the European Community* should have identified the table on page 25. We regret any inconvenience this may have caused our readers.

©NUEXCO 1987

NUEXCO

FOCUS

INDIA'S NUCLEAR INDUSTRY

Introduction

India operates six commercial reactors, having a combined capacity of 1330 MWe, and is in the process of making sizeable increases in its nuclear industry infrastructure. Total capacity under development is approximately 1900 MWe; four 235-MWe reactors are under construction, and another four are in the planning stage. Government plans call for building an additional 7,000 MWe before the end of the century, for a total of approximately 10,000 MWe, which will require more than tripling the existing and planned nuclear generating base. The achieved result will likely fall far short of the plans. In addition, India also is proceeding on fast breeder development, and recently inaugurated a 40-MW(thermal) test breeder reactor. Engineering plans for a 500-MWe prototype commercial breeder reactor are also underway. Overall, India's program is self-contained and well integrated and the country has planned extensive development of commercial nuclear power, as shown in Figure 1.

India's strategy relies on indigenous development of all aspects of the nuclear power program to the maximum possible degree. Independence in the fuel cycle, and the associated freedom from international controls and restraints, has led to a reactor program based on Pressurized Heavy Water Reactors (PHWRs), which are closely linked by design to India's two original CANDU reactors, still operating at the Rajasthan complex. The Nuclear Fuel Complex (NFC) at Hyderabad has complete fuel fabrication capability, and domestic reprocessing of spent fuel takes place at several locations. Although India can produce enough natural uranium and fabricated fuel to operate its four existing PHWRs without any need to buy fuel abroad, little surplus production capacity is thought to exist, and recent uranium discoveries have not uncovered large new reserves. Considerable expansion of the reactor program, could, in the future, result in India becoming a buyer of uranium on the world market.

Background

Since the mid-1970s, India's nuclear program has operated largely independently of the rest of the world's nuclear commerce. In 1963, India and the USA signed a nuclear cooperation agreement, in which the USA promised to provide enriched uranium fuel for US nuclear reactors then being considered by India. The 30-year agreement expires in 1993. Following the signing of the agreement, India ordered two General Electric (GE) BWRs that were built at Tarapur, north of Bombay, and placed in operation in 1969.

In 1968 India refused to sign the Nuclear Non-Proliferation Treaty, claiming it is discriminatory in that its restrictions are applied unequally. However, the 1974 explosion of what India termed a "peaceful" nuclear device strongly affected India's international political relations and its commercial nuclear power program. Prior to the bomb test, Atomic Energy of Canada Ltd. (AECL) had been heavily involved in the Indian nuclear program, in design and construction of both research and power reactors. India had selected the CANDU technology for its third and fourth reactors (Rajasthan Units 1 and 2) in part because the natural uranium fuel used by the PHWRs would not require enrichment by outside parties, but also because the fuel could be supplied largely from domestic sources, and therefore would not be subject to restrictions on its disposition after use in the reactor. Following the bomb test, however, the Canadians stopped all assistance, canceling the supply of equipment for the Rajasthan units and essentially terminating nuclear cooperation with India. Under totally Indian guidance, the Rajasthan units were eventually completed, although after considerable delays.

In 1977, the US Government announced its dissatisfaction with the 1963 bilateral cooperation agreement, a situation aggravated by India's refusal to accept full-scope IAEA safeguards over its nuclear plants. The USA stated that it would consider ending its commitment to supply Tarapur with enriched uranium through 1993. In 1978, the US Congress passed the Nuclear Non-Proliferation Act (NNPA), tying US exports of nuclear fuel and equipment to the conclusion of new bilateral safeguards agreements, in particular covering the use of spent fuel. In lieu of safeguards, the USA and India were not able to agree on rights to fuel deliveries specified under the 1963 pact. The US continued to seek a conditional termination of the 1963 cooperation agreement, but one that allowed it to keep control over reprocessing of any spent fuel coming from the Tarapur plants, and providing for inspection of plants and fuel even after the agreement's end date. Conversely, India considered the portion of the fuel supplied indigenously not to be covered by any safeguards agreement, and refused to accede to the US demand that Tarapur be kept open for inspection even beyond 1993.

Finally, President Carter approved a last delivery of US enriched uranium fuel to be made to Tarapur in the fall of 1980. Between 1981 and mid-1983, while the fuel dispute continued to be unresolved and political relations between India and the USA showed considerable strain, the Tarapur units were forced to operate at less than half of capacity. By late 1982, a partial solution was agreed upon, in which France would assume US obligations to provide India with fuel, totalling approximately 20,000 KgU as UF_6 enriched to approximately 2.7 percent U_{235}. The issue of inspections and safeguards between the USA and India was left unresolved. The first French delivery was made in May 1983.

© NUEXCO 1987

During this period, US exports of spare parts to the Tarapur plant also became a controversial issue as the US Congress viewed such export sales as a violation of the NNPA. Considering India's nuclear test and its refusal to allow indefinite inspections of Tarapur, the NRC denied export licenses for plant equipment to GE and several subcontractors. Some members of Congress argued that Tarapur had supplied at least some of the plutonium for the nuclear explosion, and could do so again in the future, therefore concluding that exporting spare parts aided India's possible nuclear weapons development program. Eventually, most of the required spare parts were either procured from European suppliers or fabricated in India.

The issue of reprocessing rights and safeguards has not subsided. Most of India's nuclear program is not covered by any international safeguards arrangement, having been built and fueled to a large extent indigenously. India steadfastly maintains that all of its plutonium resources are and will be used for peaceful projects, such as the fueling of the fast breeder reactors planned for the next century. In developmental terms, India's disinclination to abide by international safeguards conventions drastically limits its access to nuclear technology from a number of countries, including the USSR.

India's Nuclear Power Strategy

For the last few years, the official target for nuclear power production has been the installation of 10,000 MWe capacity by the year 2000, up from the 1986 figure of approximately 1,300 MWe (see Table 2). Nearly all of this nuclear expansion is expected to be of Indian design and manufacture, and the complete fuel cycle, except for part of the low-enriched fuel for Tarapur, will also be indigenous. Probably less than ten percent of plant equipment will be purchased abroad.

Since the 1950s India has advocated, and has partially implemented a three-stage approach to nuclear technology. The first stage envisions construction of approximately 8,000 to 10,000 MWe of nuclear generating capacity using Pressurized Heavy Water Reactors (PHWRs), which use natural uranium fuel. The operating units at Madras (MAPS) and Rajasthan (RAPS), and the plants under construction or planned at Narora, Kakrapar, Kaiga, and Rajasthan are all of this type, having capacities of

Table 2

NUCLEAR POWER UNITS IN INDIA

Unit	Type	MWe	Percent Complete[1]	COD[2]
In Commercial Operation				
Tarapur (TAPS) 1	BWR	210	100	1969
Tarapur (TAPS) 2	BWR	210	100	1969
Rajasthan (RAPS) 1	PHWR	220	100	1973
Rajasthan (RAPS) 2	PHWR	220	100	1981
Madras (MAPS) 1	PHWR	235	100	1984
Madras (MAPS) 2	PHWR	235	100	1985
Total MWe in Operation		1,330		
Under Construction				
FBTR[3]	FBR	15	—	1987
Narora (NAPP) 1	PHWR	235	85	1988
Narora (NAPP) 2	PHWR	235	80	1989
Kakrapar (KAPP) 1	PHWR	235	22	1991
Kakrapar (KAPP) 2	PHWR	235	17	1992
Planned				
Kaiga 1	PHWR	235	—	1994
Kaiga 2	PHWR	235	—	1995
Rajasthan 3 and 4	PHWR	235	—	late 1990s
TOTAL MWe		3,222		

[1] According to published sources.

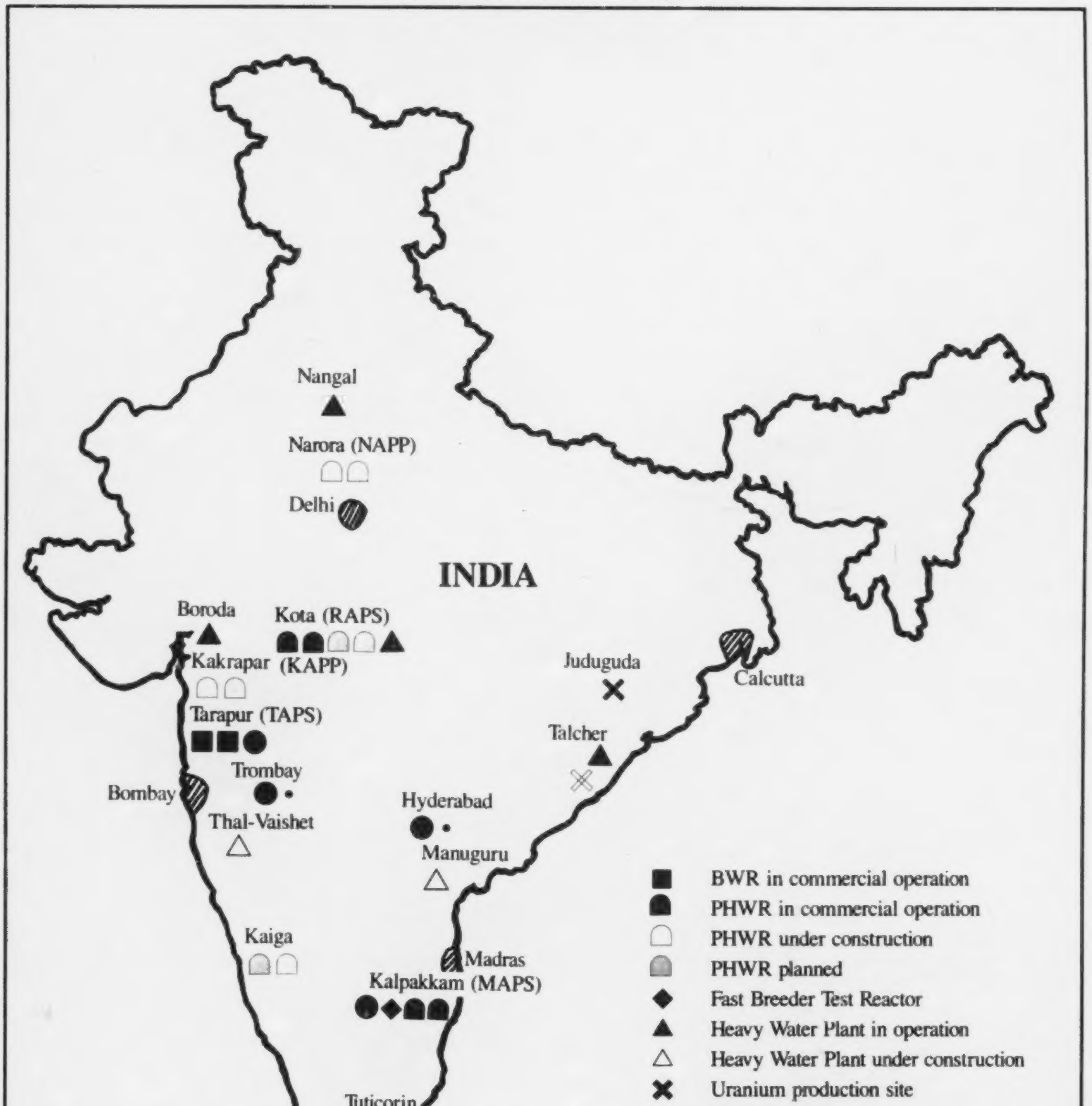
[2] COD = Actual or expected Commercial Operation Date.

[3] Fast Breeder Test Reactor. Unit being modified for electricity generation.

©NUEXCO 1987

Figure 1

DISTRIBUTION OF NUCLEAR UNITS AND URANIUM PRODUCTION AREAS IN INDIA


Nangal
Narora (NAPP)
Delhi
INDIA
Boroda
Kota (RAPS)
Kakrapar (KAPP)
Tarapur (TAPS)
Trombay
Bombay
Thal-Vaishet
Hyderabad
Manuguru
Juduguda
Calcutta
Talcher
Kaiga
Madras
Kalpakkam (MAPS)
Tuticorin
■ BWR in commercial operation
PHWR in commercial operation
PHWR under construction
PHWR planned
◆ Fast Breeder Test Reactor
▲ Heavy Water Plant in operation
△ Heavy Water Plant under construction
✖ Uranium production site
● Reprocessing plant
Thorium mining area
• Fuel fabrication facility

©NUEXCO 1987

approximately 200 MWe. The design of a 500-MWe upgraded version of the CANDU-type reactor has been under development for some time, and a number of these paired units are expected to fulfill the first-stage plan.

In the second stage, a generation of fast-breeder reactors will be fueled by plutonium derived from the first-generation reactors. Trial operation of the 40 MWt (15 MWe) Fast Breeder Test Reactor (FBTR) at the Kalpakkam complex near Madras is the first step in India's breeder program. The next step is construction of a 500-MWe Prototype Fast Breeder Reactor. Part of the test breeder experimental program includes the irradiation of a thorium blanket, the results of which will provide information about the feasibility of a thorium-U_{233} fuel cycle.

The third stage, not clearly defined to date, could involve a generation of breeder reactors based on a uranium-thorium fuel cycle. In all these developments, national self-sufficiency is an overriding goal.

India's Reactor Program

India currently has six commercial reactors in operation, with four others under construction, as shown in Table 2. Four additional units are in the preliminary stages of development. Of the six operating units, two are BWRs (396 MWe total capacity) and four are PHWRs (884 MWe total capacity). Slightly over two percent of India's electrical generation is provided by nuclear plants.

Tarapur Atomic Power Station (TAPS — note: operating facilities are called Atomic Power Stations, such as TAPS, whereas facilities under construction are called Atomic Power Projects) — The oldest commercial reactors in India, and the only ones built on a turnkey basis by non-Indian contractors, are the twin 210-MWe BWRs at Tarapur, located about 100 km north of Bombay in the state of Maharashtra. These units were built by General Electric Corporation (GE) of the USA in the late 1960s and are some of the oldest BWRs still operating. Units 1 and 2 entered service in November 1969. Participation by Indian contractors totaled approximately 30 percent of the cost of these units. By October 1985, TAPS Units 1 and 2 had passed 100,000 hours of power generation. In 1985, Unit 1 and 2 achieved availablity factors of 71 percent and 92 percent, and capacity factors of 62 percent and 84 percent, respectively.

Rajasthan Atomic Power Station (RAPS) — Located at Kota in the state of Rajasthan, the RAPS complex contains twin 220-MWe PHWRs of the CANDU type, designed by AECL. The first unit was commissioned in December 1973, using about 45 percent imported equipment. RAPS Unit 1 has experienced problems with cracks in the reactor vessel end shield, and essentially has been shut down since September 1981 The reactor was restarted in February 1985 after repairs were made, but the unit was shut down three months later when new cracks were discovered. Given the extreme difficulty of the repairs, permanent decommissioning of the reactor is a possibility. RAPS Unit 2 entered commercial service in 1981, and has operated at a capacity factor of 57 percent and an availability factor of 71 percent during 1985. The unit reached its rated power of 200 MWe in November 1985, and was built with about 70 percent Indian participation.

Madras Atomic Power Station (MAPS) — The nuclear complex at Kalpakkam, about 75 km south of Madras, contains twin units similar to those at Rajasthan, but slightly larger (235 MWe). The design and construction is almost completely domestic, and is primarily based on experience gained from the RAPS reactors. Non-Indian equipment used in the MAPS reactors is less than fifteen percent of the total, consisting primarily of instrumentation and some stainless steel components for the fuel subassemblies. The cost of MAPS Unit 1 is reportedly about US $130 million. Unit 1 entered commercial operation in January 1984, seven years after the originally planned operating date. Unit 2 achieved criticality in August 1985, and entered commercial operation in November 1985, reportedly at a cost of approximately $190 million. MAPS Unit 1 achieved a 46 percent capacity factor and a 55 percent availability factor during 1985.

The Construction Program — The Department of Atomic Energy (DAE) currently has several reactors under construction or in the advanced planning stage. In western Uttar Pradesh, near Delhi, the Narora complex has two 235-MWe PHWRs nearing completion. Under construction for the last six years, these units are scheduled for commissioning in late 1988 or early 1989, and cost estimates for both of the units total approximately US $400 million. Foreign components in the Narora project are reported to be approximately ten percent of the total. Using a design virtually identical to the reactors at Narora, the twin PHWRs at the Kakrapar Atomic Power Project (KAPP), located about 300 km north of Bombay in the state of Gujarat, are scheduled for completion by 1992. In addition, preliminary site work is advancing at Kaiga, in the southern state of Karnataka, where similar twin units are planned. The existing Rajasthan complex also is scheduled to receive two additional 235-MWe PHWRs to complement the two units already there. Reactor sites are now planned to eventually accommodate four reactors. Assuming the master plan is followed, most of India's reactor capacity through the early 2000s will come from the sites already in use or planned.

Research Reactors — India's primary nuclear research facility, the Bhabha Atomic Research Centre (BARC), operates several research reactors at its facility at Trombay, near Bombay. The largest and newest research reactor is called DHRUVA, a 100-MWt heavy-water moderated and cooled thermal neutron

©NUEXCO 1987

reactor, which became operational in August 1985. Almost immediately after startup, however, DHRUVA was shut down due to severe flow-induced vibration in the fuel bundles. Operation resumed in late September 1986, but vibration problems reportedly still hinder operation. DHRUVA is one of the largest research reactors in the world, and since it was designed and built entirely in India, is not covered under any sort of safeguards arrangement. Critics claim that the unit has plutonium production capability.

There are several other research reactors located at the BARC facility. The Apsara reactor, a 1-MWt pool-type reactor built in 1956, is scheduled to be decommissioned in the near future. The Cirus 40-MWt heavy water moderated research reactor, supplied by Canada, has been in operation since 1960. The main function of Cirus has been to generate plutonium oxide fuels, test thorium oxides for fuel potential, and produce radioisotopes. Reprocessed spent fuel from Cirus fuels the Fast Breeder Test Reactor (FBTR). Purnima II, a small research reactor using U_{233} for fuel and designed for experiments in the U_{233}-Thorium fuel cycle, recently achieved criticality. Also, at the Kalpakkam facility, a 30-KW neutron source reactor is under construction.

The Fast Breeder Reactor Program — At Kalpakkam, near Madras in the southern state of Tamil Nadu, the Indira Ghandi Centre for Atomic Research (IGCAR — formerly the Reactor Research Centre) is dedicated to the development of liquid-metal fast breeder reactor technology. One of the Centre's projects, the FBTR, achieved criticality in December 1985. The FBTR, a 40-MWt reactor based on France's Rapsodie breeder, operated successfully through its first test phase, after which it was shut down for addition of steam generators, leak detection systems, and other facilities that will enable it to produce about 15 MWe of electricity. If construction proceeds on schedule, this unit should reach rated power by 1988, at a reported cost of about $54 million. Plutonium for the first core came from the Cirus research reactor, and plutonium for reload cores will be provided by reprocessed fuel from MAPS.

The FBTR, cooled by 150 tonnes of liquid sodium, uses a domestically designed mixed plutonium-uranium carbide fuel, rather than the more common mixed oxide fuel. The initial core of 22 fuel subassemblies contains 70 percent plutonium carbide and 30 percent natural uranium carbide, a fuel mix developed and manufactured at the BARC complex. According to the Department of Atomic Energy (DAE), the carbide fuel has up to 30 percent higher heavy atom density, enabling better breeding ratios; 5 to 7 times higher thermal conductivity, which allows more heat to be extracted from a reactor column; and the carbide fuel mix is more compatible with the sodium coolant compared to mixed oxide fuels.

The test breeder's four steam generators are designed to produce superheated steam at a temperature of 480 degrees C, enabling a thermal output of 40-50 MW. In general, the FBTR exhibits a high degree of fuel burnup. Design and manufacturing expertise have been provided through technical collaboration with French industry and the French Atomic Energy Commission.

Engineering plans are underway for the 500-MWe Prototype Fast Breeder Reactor (PFBR), expected to be built before the end of the century. This unit reportedly is based on technology from France's Phenix program, and will be a "pool" type design, rather than the "loop" design of the FBTR. Using the pool design, the reactor's four primary pumps and eight intermediate heat exchangers will be located inside the reactor vessel. Manufacture of all large mechanical components is expected to take place in India, including the reactor vessel, which will be 15 m in diameter, and 13 m in height.

Nuclear Fuel Resources

Exploration, mining, and milling of uranium and thorium takes place under the auspices of the DAE. One of the first institutions started under the DAE was the Atomic Minerals Division (AMD), which operates regional centres for exploration and research. The state-owned Uranium Corporation of India Limited (UCIL) and India Rare Earths Limited (IREL) conduct production operations.

India's known reserves of uranium are not particularly large, estimated by OECD/IAEA as of mid-1985 to total 62,700 tonnes U. Of these, about 35,100 tonnes are in the under $80/kg category, about 11,000 tonnes are in the $80-130/kg category, and 17,000 tonnes are classified as Estimated Additional Resources (EAR). The major focus of uranium exploration and development has been in the Singhbhum thrust belt, west of Calcutta in the state of Bihar. Within the Singhbhum district, UCIL operates India's only commercial uranium mining facility, an underground mine and mill at Juduguda, in production since the 1960s. Output from this mine and mill is estimated to be approximately 200,000 pounds U_3O_8 per year. Mill capacity is 1,000 tonnes/day of ore, although recently a major expansion of the Juduguda mine and mill has been underway, and a new 3,000 tonne capacity ore-processing plant is being added to the existing facilities. UCIL is also working to expand production in the Singhbhum area by opening new mines at Bhatin and Turamidih. Currently, small plants at Rakha and Mosaboni also contribute to UCIL's uranium operations, operating in conjunction with the copper concentrators at copper mines of Hindustan Copper Limited. At present, one of the main objectives of India's uranium industry is to improve recovery from copper tailings.

In contrast to uranium reserves, India's reserves of thorium are estimated at over 360,000 tonnes Th. At present, commercial exploitation of these thorium deposits is under the direction of India Rare Earths Limited (IREL), a government company in operation since 1950, and is almost entirely based on mining of placer beach sands. Mineral sands separation plants operate at Manavalakurichi and Chavara, in the southern state of Kerala, and a thorium processing plant is located at Alleppey, also in Kerala.

The large mining complex in the state of Orissa, the Orissa Sands Complex (OSC), south and west of Calcutta, is undergoing a second expansion phase. OSC mines about three million tons of sands per year, and, among other important minerals such as ilmenite, rutile and zircon, they produce about 4,000 tonnes per year of monazite, a mineral containing thorium nitrate. Recoverable reserves of monazite from placer sands in India have been estimated at 146 million tonnes.

The Rare Earths Survey Unit, responsible for exploration and mineralogical surveying under the AMD, has been actively exploring for radioactive minerals in recent years. From mid-1985 to mid-1986, over 51,000 meters of exploratory drilling were completed, the major part of which has been in the Singhbhum thrust belt of Bihar. Within the last several years, several promising deposits have been discovered, but in general, these offer only a few thousand tonnes of uranium potential at any one deposit.

Fuel Fabrication and Reprocessing

The Nuclear Fuel Complex (NFC) at Hyderabad is the main fuel fabrication unit in India, although some nuclear fuel also is produced at BARC. The complex produces natural UO_2 fuel bundles for the RAPS and MAPS reactors, as well as enriched uranium fuel assemblies for the Tarapur BWRs. The facility also produces the core axial subassemblies and thorium blanket subassemblies for the FBTR. As part of its comprehensive fuel production capability, the NFC also manufactures zircaloy and zirconium-niobium alloys for fuel element cladding.

Recent NFC expansion plans include doubling uranium oxide fuel capacity to around 180 tonnes per year, and increasing capacity for complete fuel assemblies to about 50 tonnes per year. Originally designed to produce 100 tonnes per year of PHWR fuel and 35 tonnes of finished zircaloy products, the expansion will enable the NFC to produce over 200 tonnes of PHWR fuel and 50 tonnes of zircaloy products. PHWR fuel is made from magnesium diuranate, which is then converted into UO_2, while BWR fuel is fabricated from imported UF_6.

Reprocessing of spent fuel takes place at several DAE facilities. India's first reprocessing plant was built at the BARC complex in Trombay, and was commissioned in 1964 with a capacity of about 30 tonnes per year. The Indian-designed and built plant uses the Purex process with solvent extraction columns. Fuel reprocessed at BARC comes mainly from the Cirus reactor, located on site.

The primary reprocessing plant at present (called PREFRE) is located at the Tarapur reactor site, where since 1982 spent fuel from the Tarapur reactor has been reprocessed. This facility has a rated capacity of 100 tonnes per year. In 1986, the Tarapur plant also reprocessed spent fuel from the MAPS Unit 1 reactor, and the plutonium was destined for use in the FBTR. This plant operates under international safeguards only when reprocessing safeguarded material, such as enriched UF_6 imported from France. When reprocessing domestic fuel material, no safeguards apply to its operation.

At the reactor complex at Kalpakkam, the site of the MAPS and FBTR units, DAE is building a plant for reprocessing spent zircaloy-clad UO_2 fuel from MAPS, having an estimated capacity of 100 tonnes per year. The production line also is designed to accept mixed carbide, and possibly nitride, spent fuels from the breeder reactor program. Also at Kalpakkam, a fuel reprocessing development laboratory has been set up as part of the IGCAR facility.

Heavy Water Production

India's PHWR reactor program depends to a great extent on an adequate supply of heavy water — deuterium (D_2O) — and is committed to domestic supply. Indian nuclear authorities admit that loss of heavy water is one of the recurring problems encountered in running the existing PHWRs, which use the product both as moderator and as coolant. At present, while India's production of heavy water is close to meeting its requirements, some is regularly imported from the Soviet Union. In order to meet requirements for the series of reactors under construction and planned for the immediate future, an expansion and upgrading program of heavy water production facilities is now underway.

Several plants are operated in conjunction with fertilizer plants, using synthesis gas as feedstock in a bithermal ammonia-hydrogen exchange process. Other inputs obtained from the fertilizer plants are ammonia, steam, and nitrogen. These plants have been particularly affected by problems associated with their dependence upon the fertilizer plants, such as poor or intermittent electricity supply, and interruptions in supply of feedstocks and other necessary inputs. At Boroda and Tuticorin, the synthesis gas has at times also contained less than design levels of deuterium. Since efficient operation of the heavy water plants depends to a great extent on smooth, uninterrupted operation, such problems have caused production to be considerably reduced from rated capacity in some cases. The most serious problems could be greatly helped by the addition of independent, captive electrical power and steam supplies to each plant. In general, the heavy water plants operated in conjunction with fertilizer plants use the ammonia-hydrogen exchange process, while others use the hydrogen sulfide-water exchange process.

Existing Heavy Water Plants

1. The Nangal unit, in the state of Punjab, operates in conjunction with a fertilizer plant, using ammonia-hydrogen exchange. It is India's oldest and smallest heavy water plant, first started up over 20 years ago. Capacity is rated at 14 tonnes per year.

2. The plant at Boroda, in Gujarat, has a rated capacity of 67.2 tonnes per year using the ammonia-hydrogen process. Because of frequent interruptions in feedstock and power supplies coming from the fertilizer plant it operates with, maximum production has effectively been only about 45 tonnes per year. Upgrading may allow it to achieve rated capacity in 1987 or 1988.

3. The Kota plant, located at the site of the RAPS reactors in Rajasthan, operates by the bithermal hydrogen sulfide-water exchange process. Water is used as feedstock, and a 5-stage vacuum distillation is used for final enrichment. Design capacity is rated at 100 tonnes per year, but effective capacity has been about 85 tonnes.

4. The plant at Talcher, in Orissa, is dependent upon an ammonia fertilizer plant, and uses the bithermal ammonia-hydrogen exchange process. Synthesis gas is used as feedstock. In April, 1986, a fire caused heavy damage to the Talcher facility. Capacity is rated at 71 tonnes.

5. The Tuticorin plant, in Tamil Nadu, produces heavy water using the ammonia-hydrogen process. Its rated capacity is 71.2 tonnes per year, however effective capacity has been around 50 tonnes. Upgrading is expected to increase production to near design capacity in 1987.

Several other heavy water plants are planned or are under construction. The Thal-Vaishet project, near Bombay, is scheduled for completion in 1987. It uses an ammonia-hydrogen process similar to that used at the Tuticorin facility, and has a rated capacity of 100 tonnes per year. Construction has also started on a new plant at Hazira, in Gujarat, identical in design to Thal-Vaishet. Rated capacity is 100 tonnes, and operation is expected by 1991. A new unit at Manuguru, in Andhra Pradesh, is also under construction, expected to be operational by 1988. It uses the hydrogen sulfide-water process, and has a capacity rated at 185 tonnes.

The five currently operating heavy water plants together have a capacity of between 250 and 325 tonnes D_2O per year. According to Indian sources, meeting the ambitious goals set in the national expansion plan for 10,000 MWe of PHWR capacity will require about 12,000 tonnes per year of heavy water production capability, if self-sufficiency is to be attained. Assuming new heavy water plants begin production exactly as planned, and run at design capacity, by 1992 overall heavy water production capacity will have roughly doubled from the present, to around 600 tonnes per year. During 1985-1986, the heavy water program was allotted nearly 30 percent of the DAE budget.

Conclusion

Prime Minister Rajiv Ghandi has often made reference to India's announced intent to build 10,000 MWe of nuclear capacity by the year 2000. The main thrust of India's commercial nuclear planning is still based on PHWR technology, both because of the experience gained using that reactor type, and because its natural uranium fuel enables India to provide most or all of the fuel requirements, something of great importance in its planning. In addition, fast breeder technology is expected to contribute to nuclear generating capacity sometime in the early 2000s.

India's goal of reaching 10,000 MWe of nuclear generated electrical capacity by the end of the century appears to be quite optimistic. Assuming that all existing reactor capacity is available (1,345 MWe), and that the Narora, Kakrapar, Kaiga, and Rajasthan projects are complete and operating at rated capacity (1,880 MWe) by 2000, the installed nuclear base can be estimated at about 3,200 MWe.

To achieve the additional 6,800 MWe capacity needed to reach the 10,000 MWe goal, several options are available, assuming domestic manufacture and development. Using the 235-MWe PHWR type, for which the design and construction capability is already largely in existence, 15 more twin-unit projects would need to start construction by the early 1990s. An alternative, of unproven merit, would be to introduce the 500-MWe version of the PHWR that has been in design for some time, and which is considered the sucessor to the 235-MWe size. Also, the possibility exists of one fast breeder reactor in operation by 2000, the prototype 500-MWe unit. In any case, reaching the 10,000 target will require more than tripling the existing or firmly planned reactor base.

Although India's present uranium production capability appears adequate to provide fuel supplies for the four operating PHWRs, there is little surplus production available for many new reactors. The feasibility of using thorium as fuel has yet to be demonstrated, and new discoveries of uranium have not proved to be of major significance. It is possible that in the future, if the nuclear expansion program is continued, India could become a buyer on the world uranium market.

©NUEXCO 1987

1986 US URANIUM ACTIVITIES

Introduction

Throughout 1986, two main factors affected the US uranium industry; the uncertainties created by the unresolved US producers vs. DOE lawsuit in the Tenth Circuit Court of Appeals, and the low uranium prices on the spot market. However, one encouraging sign was the fact that production rose for the first time in five years. Nuexco estimates 1986 US uranium production from all sources at approximately 13.8 million pounds U_3O_8, a 22-percent rise from the 1985 figure of 11.3 million pounds.

Current production sources include conventional mining and milling, by-product recovery, and solution mining. Six conventional mills were in production at least part-time throughout the year compared to five in 1985. In addition, Homestake Mining Company's mill in Grants, New Mexico operated on a limited schedule, processing small tonnages of ore at various times during the year. Production from conventional sources totaled 8.7 million pounds, almost two-thirds of which came from Chevron and Energy Fuels (and its partners). Table 3 lists the operating status of conventional uranium mills in the USA.

By-product production, including recovery from phosphoric acid and water from underground mines, totaled slightly over 3.6 million pounds, a small increase from the previous year. Uranium was recovered from phosphoric acid at several sites. International Minerals and Chemical Corporation (IMC) continued production at its Plant City and New Wales, Florida operations. No production was reported from IMC's Bartow plant. Freeport Uranium Recovery Company produced from plants located at Donaldsonville and Uncle Sam, Louisiana. The joint venture of Earth Sciences Resources Ltd., and Urangesellschaft mbH (UG) produced uranium from phosphate rock mined in Idaho and processed at an acid plant near Calgary, Alberta, Canada. For the first time in four years there was no production from oxidized copper ores and from leaching copper waste dumps.

Production from solution mining totaled about 1.5 million pounds, of which more than 1.4 million pounds was produced in the South Texas district and the remainder in Nebraska and Wyoming. There was a decrease of 650,000 pounds in uranium from solution mining in 1986, all from the South Texas district.

Project Activity

Surface drilling activity did not change significantly in 1986. Nuexco estimates that a total of 1.9 million feet were drilled, up slightly from 1.8 million feet in 1985. Approximately 70 percent consisted of exploration drilling in search of new deposits; development drilling, used to define the extent and grade of ore deposits, accounted for the remainder. Approximately 60 percent of exploration drilling took place in the South Texas district; the remaining 40 percent was evenly split between northern Arizona and all other areas combined. Approximately 60 percent of development drilling was split between South Texas and Wyoming, primarily the Powder River Basin. Of the remaining 40 percent, about 25 percent was confined to northern Arizona and 15 percent to other districts, notably Nebraska.

Important exploration successes were limited to high-grade mineralization discovered in breccia pipes in northern Arizona, and lower-grade ore zones associated with extensions along known mineral trends, primarily in Tertiary sediments of South Texas, Nebraska and Wyoming. In southeastern Utah, the Salt Wash Member of the Morrison Formation (Jurassic age) and the Shinarump Conglomerate/Monitor Butte channel sequence (Triassic age) have attracted the most interest. The main area of interest in southwestern Colorado (the Uravan Mineral Belt) is the Salt Wash sandstone. In addition to several major mining companies, there are perhaps five or six independent miners now operating in the Utah/Colorado area — another indication that the domestic uranium situation may be improving gradually.

Arizona — The number of companies actively exploring for uranium mineralization associated with solution-collapse breccia pipe structures in the Arizona Strip decreased during 1986. Four major mining companies remain active, but only one or two independent operators are still in the region. Overall, the land position is rather stable — Energy Fuels Nuclear controls about one million acres, Rocky Mountain Energy controls almost 200,000 acres, Pathfinder Mines Corporation controls about 165,000 acres, and perhaps 30,000 to 40,000 acres are under Uranerz Exploration and Mining Limited's control. Energy Fuels is conducting four separate joint ventures for exploration or orebody development throughout the district.

Each company continues to evaluate the potential of new lands, beginning with district reconnaissance. The company identifies a favorable breccia pipe prospect, and attempts to secure an adequate land position. In turn, geophysical and geochemical studies are conducted as a prerequisite to more costly exploration methods. If the study results are positive, exploration drilling is initiated. The discovery of mineralization is followed by detailed development drilling. Complete orebody evaluation is usually accomplished only by sinking a vertical shaft to expose the deposit to geologic study, long-hole drilling, bulk sampling and metallurgical evaluation. Only then can orebody configuration and contained pounds of uranium be determined, and a mine plan and recovery schedule formulated.

Energy Fuels, in conjunction with its partners, continues production from three mines — the Hack 2, Hack 3 and Pigeon. (Stockpiled ore from these mines presently supplies the White

Table 3

1986 OPERATING STATUS OF CONVENTIONAL URANIUM MILLS IN THE USA

Company	**Approximate Operating Schedule**	**Rated Capacity**[1]	**Location**
Active Mills			
Chevron Resources Co.	Full	2,500	Hobson, Texas
Cotter Corp.	1/3	1,200	Cañon City, Colorado
Homestake Mining Co.	Partial	3,400	Grants, New Mexico
Pathfinder Mines	1/3	1,800	Shirley Basin, Wyoming
Rio Algom Corp.	Full	750	La Sal, Utah
Umetco/Energy Fuels Nuclear	Full	2,000	Blanding, Utah
Inactive Mills[2]			
American Nuclear Corp.	Inactive	950	Gas Hills, Wyoming
Anaconda (ARCO)	Inactive	6,000	Grants, New Mexico
Atlas Minerals	Inactive	1,400	Moab, Utah
Bear Creek Uranium	Dismantled	2,000	Powder River Basin, Wyoming
Bokum Resources Corp.	Inactive	2,000	Marquez, New Mexico
Conoco/Pioneer	Dismantled	3,400	Falls City, Texas
Dawn Mining Company	Inactive	450	Ford, Washington
Exxon Minerals Company	Dismantled	3,200	Powder River Basin, Wyoming
Quivera Corp. (Kerr-McGee)	Inactive	7,000	Grants, New Mexico
Minerals Exploration Company	Inactive	3,000	Red Desert, Wyoming
Pathfinder Mines	Under Renovation	2,500	Gas Hills, Wyoming
Petrotomics Company	Dismantled	1,500	Shirley Basin, Wyoming
Plateau Resources Ltd.	Inactive	1,000	Ticaboo, Utah
Sohio Western Mining	Dismantled[3]	1,600	Seboyeta, New Mexico
Umetco (Union Carbide)	Inactive	1,300	Uravan, Colorado
Umetco (Union Carbide)	Inactive	1,400	Gas Hills, Wyoming
UNC Resources	Inactive	3,000	Church Rock, Wyoming
Western Nuclear Inc.	Inactive	1,700	Jeffrey City, Wyoming
Western Nuclear Inc.	Inactive	2,000	Wellpinit, Washington

[1] Capacity in tons per day.

[2] Mill inactive throughout 1986.

[3] Began dismantling in September 1986.

©NUEXCO 1987

Mesa mill at Blanding, Utah.) The Kanab North deposit is in the late development stage. The shaft was completed to a depth of 1,590 feet, and lateral development into the ore zone from the 1,530 foot level is currently underway . At the Pine Nut deposit, shaft sinking began at the end of 1986. Shaft site preparation is also in progress at the Canyon deposit. In addition, Energy Fuels is currently evaluating additional pipes with identified mineralization. The active mines as well as the Kanab North and Pine Nut deposits are located north of the Colorado River; the Canyon site represents the only development activity south of the river, although several promising structures are being evaluated at this time.

The other three companies are conducting exploration activities throughout their respective land positions, both north and south of the Colorado River. Pathfinder Mines has identified six mineralized pipe structures, five of which are located in the Antelope Valley area of the central Kanab Plateau district, north of the Colorado River. Two pipes have been defined by surface drilling, but additional drilling is needed on the other four pipes, including the site located south of the river. Rocky Mountain Energy and Uranerz have not announced exploration results to date, although both have been active in the district for several years.

Texas — Production by solution mining methods totaled almost 1.5 million pounds U_3O_8, the lowest amount in the last five years. Six companies reported production, but only Everest Minerals Corporation and the US Steel/NM Uranium joint venture operated at close to a full schedule, together accounting for over one million pounds of the total. The other four companies, in the midst of partial or full restoration programs, produced small quantities. Solution mining projects and the status of each are listed in Table 4.

Conventional production in Texas was limited to the Panna Maria mill at Hobson. Chevron Minerals Corporation, operator of the mill, produced over one million pounds U_3O_8 by processing ore transported from its Mt. Taylor mine, located in the Ambrosia Lake district of New Mexico. No ore was produced by conventional mining in Texas during 1986.

Five companies conducted exploration drilling, the same number as in 1985. As in previous years, the primary target was new ore deposits in the Goliad Formation (Pliocene age), which may have the greatest potential for larger and higher-grade deposits, as well as favorable leaching characteristics. The main exploration effort continued along trend extensions through Brooks, Duval, Jim Wells, and Kleberg counties. Exploration for new desposits in the Oakville and Catahoula formations (Miocene age) occurred in Live Oak and Bee counties as well. The rate of success is unknown, as no discoveries were announced.

Table 4

SOLUTION MINING PROJECTS IN THE USA

Project	Status
Chevron Minerals Corporation	Palagana project in full restoration.
Everest Minerals Corporation	Mt. Lucas project in full production; Tex-1 pilot project on standby; Los Palmas in final restoration.
Intercontinental Energy Corporation	Zamzow project in final restoration phase; Lamprecht project entering new production/restoration phase.
Mobil Alternative Energy, Incorporated	Holiday-El Mesquite-O'Hern project in production/restoration phase.
Uranium Resources Incorporated (URI)	Bruni and Benavides projects in final restoration phase.
US Steel Corporation	Burns project in full restoration; US Steel/Niagara Mohawk Uranium, Clay West project in production/restoration phase.

Wyoming — Only one conventional project operated throughout the year. Production from Pathfinder's Shirley Basin open-pit mine and acid leach mill totaled about one-third nominal capacity. The company currently is stripping the overburden from the adjacent property acquired from Petrotomics in 1985. That ore zone is an extension from Pathfinder's No. 2 Pit, which is essentially mined out. Eventually, waste material from the new pit will be used for backfilling in the No. 2 Pit. The new ore source is expected to add several years to the life of the Shirley Basin operation.

Interest in solution mining is limited to the South Powder River Basin, where the only sustained production comes from the Bill Smith project operated by Sequoyah Fuels Corporation (a subsidiary of Kerr-McGee Corporation). Everest Minerals Corporation continues to evaluate its Highland property (acquired from Exxon in 1984) as it awaits finalization of the permitting and licensing process. Plant construction is scheduled to begin in 1987, followed by production in 1988. In August, Malapai Resources initiated a solution mining pilot test on the Willow Creek deposit located on the Christensen Ranch property. Permits for the project allowed testing of sodium and

©NUEXCO 1987

bicarbonate lixiviants at separate sites. The sodium test was completed by the end of the year, and startup of the restoration phase is contingent upon agency approval. The bicarbonate test will begin in early 1987.

In general, exploration activity was confined to annual assessment requirements associated with mining claims scattered throughout each Tertiary basin in the state. A number of companies and individuals continue to maintain their property positions in anticipation of a resurgence in the uranium industry. Other specific areas of exploration and development drilling activity included Green Mountain, located south of Jeffrey City in Fremont County; Shirley Basin; the Gas Hills; and the South Powder River Basin in Converse County. Everest Minerals completed over 200,000 feet of drilling on the Highland site in preparation for solution mining.

Nebraska — Exploration and development consisted of Ferret Exploration Company's activities in Dawes and Box Butte counties. Ferret initiated a solution mine pilot test on the Crow Butte deposit in August, operating at a rate of 100 gallons per minute. Two wellfield patterns are involved, one of which is scheduled to demonstrate restoration procedures in early 1987. The other wellfield may be the basis for later expansion to commercial production. The success of the pilot operation to date indicates the ore deposit is amenable to solution mining techniques. As sole owner of the project, Ferret is structuring a joint venture whereby it will remain as project operator. Joint venture negotiations were in progress as of the end of the year.

Ferret continued to evaluate the Big Red claim group, which covers the trend extension of the Crow Butte deposit. Exploration and fill-in drilling completed in 1986 produced favorable results. The company is optimistic about project potential at this time, and has scheduled additional drilling in 1987.

Utah — Two conventional processing mills operated full time throughout 1986. Rio Algom Corporation's mine and mill at La Sal processed ore from its Lisbon mine, supplemented by ore purchased from a few independent mine operators. Rio Algom is scheduled to continue operation through 1987. The Umetco/Energy Fuels mill at White Mesa also operated for the entire year, fed with ore from mines in the Arizona Strip owned by Energy Fuels and its Swiss partners. Umetco processed no ore through the mill in 1986. In addition, the mill processed ore from independent miners. The mill is scheduled to continue operations through the first four to six months of 1987.

Exploration activity occurred on a limited basis, primarily as required to maintain mining lode claims. Areas of interest included the Lisbon Valley, White Canyon, Cottonwood Wash and Elk Ridge areas. Overall, exploration efforts were directed at possible trend extensions of the large high-grade ore deposits which were mined during the past 30 years. The target of exploration in the Lisbon Valley is new ore deposits in the Mossback Member of the Chinle formation (Triassic age), and the underlying Cutler Formation (Permian age); in White Canyon and Elk Ridge, companies are focusing on ore in the Shinarump Conglomerate (Triassic age); in Cottonwood Wash the target is ore in the Salt Wash Member of the Morrison Formation (Jurassic age).

Colorado — Cotter Corporation operated the Cañon City mill at about one-third capacity throughout the year, using ore from the Schwartzwalder mine located near Golden. The ore is trucked to the mill site where it is stockpiled for later milling. Production at the Schwartzwalder mine has been maintained at about 400 short tons per day. However, Cotter announced in January 1987 that uranium production operations had been suspended pending an improvement in the uranium market.

Exploration and development focused primarily on the south end of the Uravan Mineral Belt in southwestern Colorado, and is an extension of the activity in Utah. In the same vicinity, Umetco, Cotter, and others completed annual claim requirements and maintained some mines on a standby basis. Mine production reached an all-time low, as only one independent miner produced from a deposit in the Salt Wash formation, located on the Utah/Colorado border.

©NUEXCO 1987

Table 5

1986 Uranium-Related Activities in the USA

Month	Organization	Event or Announcement
January	Sequoyah Fuels	Accident at the conversion facility disrupted slurry deliveries from small solution miners. Some projects were forced to curtail operations.
January	Phillips Minerals	Announced it will abandon the Nose Rock mine project, Grants Mineral Belt, New Mexico.
March	Chevron Corporation	Announced mining would continue at Mt. Taylor, Ambrosia Lake district, New Mexico.
March	State of New Mexico	Requested that NRC assume regulatory responsibility for uranium mill tailing sites.
April	Uranium Resources, Inc.	Requested permit to solution mine Kingsville Dome deposit, Kleberg County, Texas.
April	Philadelphia. Electric Company	Transferred its 50-percent interest in the Lee mine, Ambrosia Lake district, New Mexico, to Quivira Mining Co., the original owner.
April	Public Service Electric & Gas Company	Terminated 1976 uranium supply contract with Homestake Mining Co.
April	Senator Domenici (R, New Mexico)	Introduced amendment to the Uranium Mill Tailings Reclamation Act of 1985, proposing to reduce uranium imports to 50 percent, establish plan to pay for cleanup of mill tailings, and reorganize the DOE uranium enrichment program. (The bill was not passed in that session of Congress, but could be reintroduced during 1987.)
May	Nuclear Regulatory Commission	Allowed Sequoyah Fuels to start receiving shipments of yellowcake. Small miners began to make slurry shipments.
May	Chevron Resources	Secured a one-year option to purchase the Rhode Ranch deposit, South Texas district.
May	UG USA Inc.	Announced intent to produce byproduct uranium in 1987 at the Bartow, Florida phosphate plant (the uranium plant was purchased from Westinghouse in 1986).
May	Ferret Exploration Company	Purchased Wyoming Fuel Company's 50-percent interest in the Crow Butte project, northwestern Nebraska.
June	US District Court	Ordered DOE to limit amount of foreign uranium it enriched for US utilities to 25 percent of total through 1986, and none thereafter.
June	Nuclear Regulatory Commission	Agreed to assume regulatory authority over New Mexico uranium milling operations.
July	US Department of Energy	Was granted a stay pending appeal of Judge Carrigan's order.
July	Rocky Mountain Energy	Announced signing of a five-year joint venture agreement with Taiwan Power Company for uranium exploration in the USA.
September	Sohio Western Mining	Initiated plan to decommission L-Bar mine and mill, Seboyeta, New Mexico.
September	Uranium Resources, Inc.	Submitted plan to Texas regulatory agencies for solution mining the Rosita deposit, South Texas district.
September	ARCO, et al	Relinquished to US Energy Corp. their mining lease on the APT deposit, Green Mountain district, Wyoming.
October	US Congress	Banned import of uranium ore and concentrates from South Africa.

©NUEXCO 1987

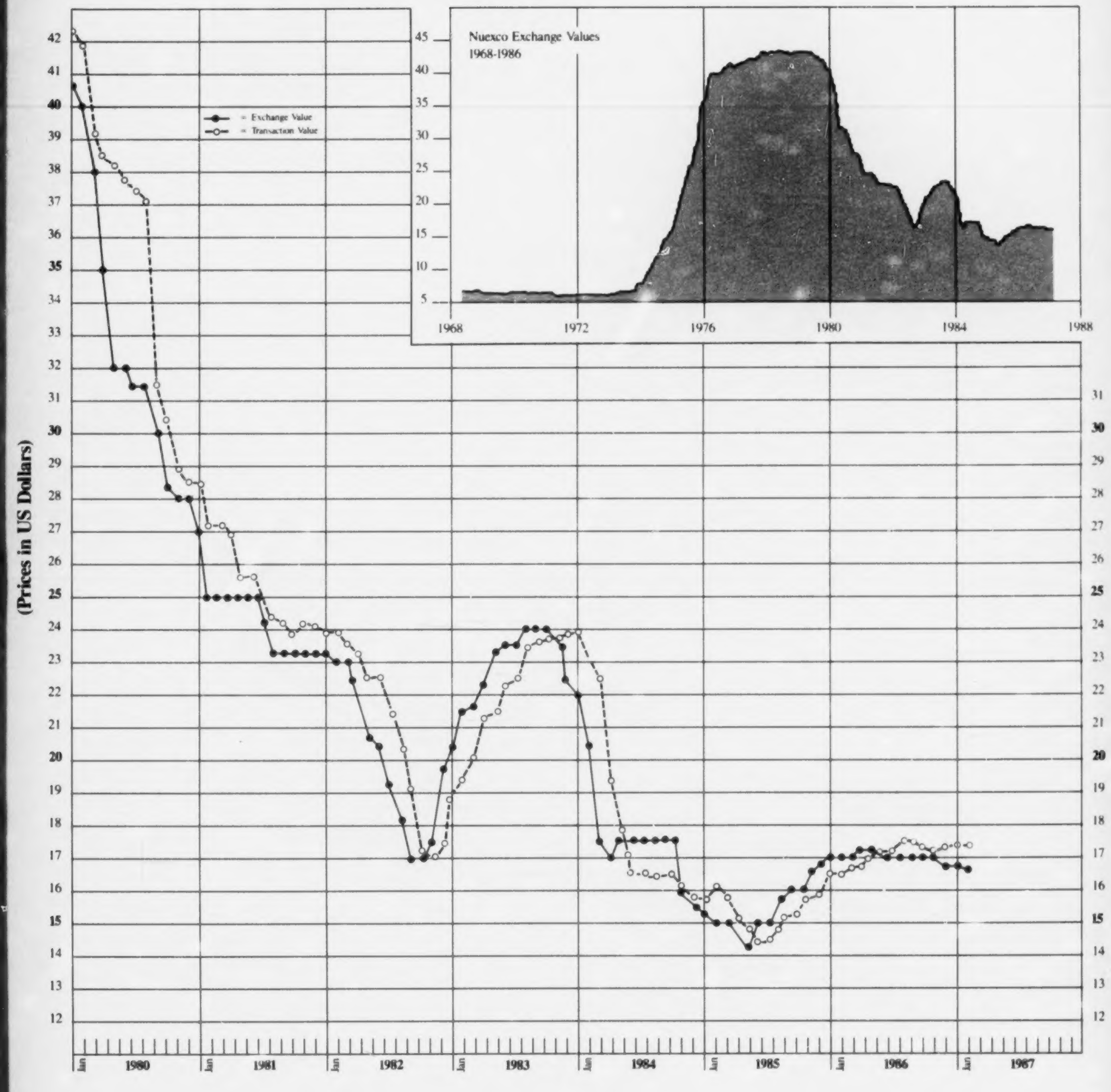
Table 5

1986 Uranium-Related Activities in the USA

Month	**Organization**	**Event or Announcement**
October	American Nuclear	Sought NRC and Wyoming state approval to move 1.5 million yards of mill tailings from abandoned Riverton, Wyoming site to ANC tailings site in Gas Hills, Wyoming.
October	Altair Resources	Began ground water treatment at the Bison Basin site, Red Desert, Wyoming under contact to the Wyoming Department of Environmental Quality.
October	Sequoyah Fuels	Conversion facility allowed to resume operations, after being closed since January accident.
November	Uranium Resources, Inc.	Received approval from Texas Water Commission to solution mine the Kingsville Dome deposit.
November	Union Carbide Corporation	Agreed to pay $42 million in reclamation costs at its Uravan, Colorado mill site.
November	Homestake Mining Company	Announced plan to reduce mining rate, Ambrosia Lake, New Mexico to 50 t/d from current rate of about 130 t/d.
December	Energy Fuels Nuclear	Began negotiating to purchase Quivira Mining Corporation, Ambrosia Lake, New Mexico.
December	US Department of Energy	Energy Secretary John Herrington declared US uranium industry nonviable in 1985, for the second consecutive year.

©NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	**16.65**											

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	**17.35**											

©NUEXCO 1987

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	**1.80**											

HISTORICAL UF_6 VALUES

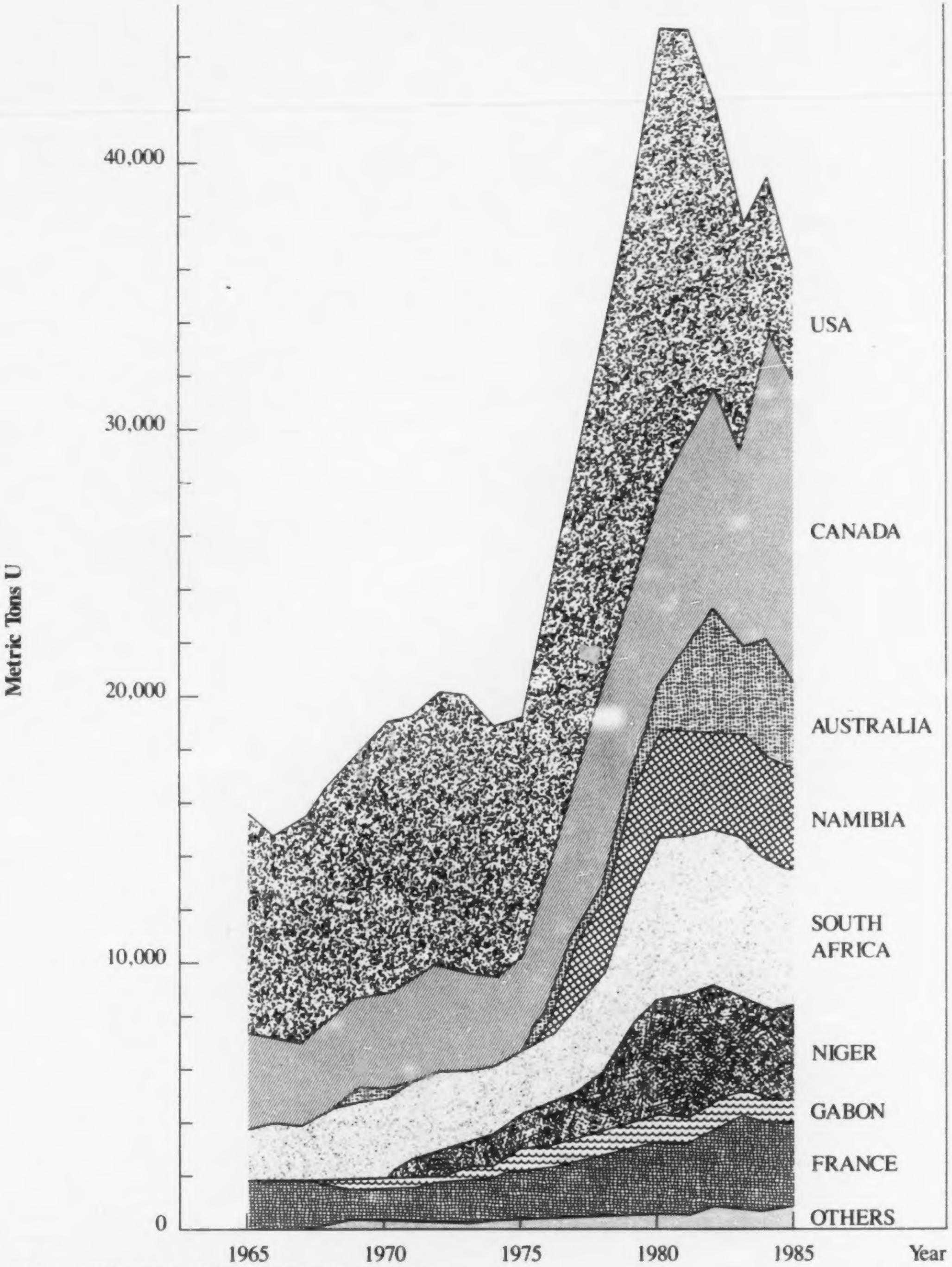
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	**47.75**											

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

©NUEXCO 1987

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[2] (1976 = 100)
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3] [4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7	202.5
Oct 1985	108.4	202.4
Nov 1985	109.4	209.9
Dec 1985	110.0	210.0
Jan 1986	109.6	210.0
Feb 1986	108.7	210.0
Mar 1986	99.5	210.5
Apr 1986	94.3	210.5
May 1986	93.5	210.5
Jun 1986	95.7	210.5
Jul 1986	98.1	215.2
Aug 1986	98.2	215.2
Sep 1986	105.6	215.3
Oct 1986	106.1	215.4
Nov 1986	—	215.6

P = Preliminary   R = Revised since last month

[1] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4] Annual averages prior to 1979 reflect index base no longer in use.

[5] Monthly data for 1979-82 appear on page 35 of Report 184.

[6] Annual averages are for financial year ending June 30.

©NUEXCO 1987

GOVERNMENT STATISTICS

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8R	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.3R	19.32	16.62R	15.78R	13.14R	11.45R	12.90R
Oct 1986	119.8	19.97P	16.80P	15.92P	13.21P	11.49P	12.89P
Nov 1986	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

©NUEXCO 1987

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,995
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140R	516,832
Aug	1986	—	—	232.2	220.3	760,925	502,968
Sep	1986	81.94	181.8	236.7	221.9	764,562	510,665
Oct	1986	—	—	239.3	226.8	—	—
Nov	1986	—	—	242.4	230.2	—	—
Dec	1986	85.38	189.9	244.9	—	—	—

P = Preliminary   R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9R	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.8	297.7	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.3	298.3	330.5	—	12.91R	13.29R	12.08	9.72R
Nov 1986	309.8	298.7	330.8	—	12.78P	13.31P	12.14R	9.74R
Dec 1986	309.3	298.1	331.1	115.3	—	—	12.19P	9.87P

P = Preliminary   R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.

Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.

Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.

Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

REPRESENTATIVES AND CONSULTANTS

JAPAN

Kazy Yokota
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA

Chris I. Von Christierson
Southern Prospecting (Pty) Limited
P.O. Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telephone: (27-11) 838-1868
(27-11) 834-4211
Telecopy: (27-11) 834-3148
Telex: 4-89878 SA

TAIWAN

Edward Bee
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX: 785-11570 (BEELIANG)

UNITED STATES

Harold C. Lindberg
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

Ralph O. Smith
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T. J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O. J. C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C. C. Stewart
(U.K.)

W. Bryan Webster
(USA)

B6800-1 A
3/17/87

NUEXCO

Monthly Report

March 1987 Number 223

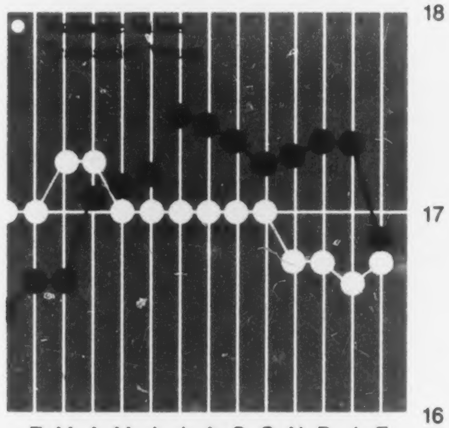
Nuexco Increases Uranium Consumption Forecast.

Potential US Retaliation Against Canadian Upgrading Policy.

US Ban on South African Uranium Imports Examined.

NWPA Update.

Solution Mining of Uranium, Part 2.



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central 1515 Arapahoe Street, Suite 900 Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

DIRECTOR OF OPERATIONS — Transaction Services	James E. Lewis
DIRECTOR OF OPERATIONS — Information Services	J. Fred Lawrence

Manager of Fuel Transactions	Earl E. Hoellen, Jr.

Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols
Manager of Information and Consulting	R. Wesley Miller

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO

NUEXCO REPORT 223 FIGURES OF THE MONTH (February 28, 1987)	This Month (Report 223)	Last Month (Report 222)	12 Months Ago (Report 211)
Exchange Value[1]	16.75	16.65	17.00
Transaction Value[1]	16.90	17.35	16.70
UF_6 Value[2]	48.00	47.75	48.00
Loan Rate[3]	3%	3%	5%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	3.4	3.8	2.4
Near-Term Uranium Demand[6]	2.3	2.1	1.0
Near-Term Supply-Demand Ratio	1.5	1.8	2.5
Recent Uranium Sales:			
Number of Transactions[7]	9	4	5
Quantity of Material[8]	2.1	3.6	1.0
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	80	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	459	457	462
3.0 w/o U_{235}	586	588	592
3.5 w/o U_{235}	719	717	724
4.0 w/o U_{235}	852	849	858

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (222)

Section	Topic	Page
Canada	Uranium Mining Moratorium in BC to Lapse	11
South Africa	Fourth-Quarter and 1986 Production Results	11
United Kingdom	Sizewell Inquiry Report Issued	12
United States	AIF Group Report Supports Standardization of Nuclear Plants	13
	Reagan Administration Drops AVLIS Program from 1987 Budget Request to Congress	14
Focus	India's Nuclear Industry	16
Raw Materials	1986 US Uranium Activities	23
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in January 1987	1
	Enriched Uranium and SWUs Pricing in January 1987	2

©NUEXCO 1987

NUEXCO

EXECUTIVE SUMMARY
REPORT 223
(All data as of February 28, 1987)

Exchange Value
\$16.75, up \$0.10

The **Exchange Value** is **\$16.75** per pound U_3O_8, up \$0.10 since last month.

UF_6 Value
\$48.00, up \$0.25

The **UF_6 Value** is **\$48.00** per kilogram U as UF_6, up \$0.25 since last month.

Transactions

Nine recent natural uranium sales are reported, involving **2.1 million** pounds equivalent U_3O_8 in the near term. All of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. Three of the transactions involved natural UF_6.

Supply-Demand Ratio
decreased to 1.5 to 1

Active spot and near-term **uranium supply** amounts to **3.4 million** pounds U_3O_8 equivalent, down 400 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.3 million** pounds, up 167,000 pounds from last month. The spot and near-term **supply-demand ratio** decreased to **1.5 to 1.**

Transaction Value
\$16.90, down \$0.45

The **Transaction Value** is **\$16.90** per pound U_3O_8, **down \$0.45** since last month. The calculation includes 12 transactions involving a total of 2.5 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate
unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value
\$1.80, unchanged

The **Conversion Value** is **\$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 915 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

SWU Value for
delivery within
one year: \$80, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **\$80** per SWU, unchanged since last month. Three secondary market SWU transactions are reported.

* * *

Analysis and
Commentary

The 1987 edition of Nuexco's Uranium Market Study and Price Forecast shows a fundamentally different uranium consumption forecast, which significantly affects our forecast of future uranium prices. Improvements in reactor operating results in the past three years have led to an altered forecast of plant capacity factors. Natural uranium consumption is forecast to grow, in the reference case, from 106 million pounds U_3O_8 in 1985 to 145 million pounds in 2000.

United States

The Department of Energy recently sent to Congress a revised draft Mission Plan that officially postpones the date on which DOE expects to be able to receive high-level waste materials into the first repository stipulated in the Nuclear Waste Policy Act of 1982 (NWPA). This article presents an updated account of the recent actions by DOE in implementing the NWPA.

United States

Many nuclear-related legislative and legal issues are being addressed at present or in the near future. A new trade bill could impose a tarriff on uranium from countries requiring mandatory upgrading to UF_6; confusion exists over implementation of the ban on imports of South African uranium; renewal of the Price-Anderson Act is scheduled for debate in Congress; critics question DOE's role in implementing the Nuclear Waste Policy Act.

Raw Materials

Solution mining of uranium has undergone a long process of development since the first projects began in the USA in the early 1960s. Part 2 of this article on solution mining describes current project activity in the USA, and examines regulatory requirements, wellfield procedures, and uranium extraction technology.

This Executive Summary may be reproduced for internal distribution.

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

March 1987 No. 223

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

ANALYSIS AND COMMENTARY

World Uranium Consumption Forecast, 1987–2000 12

RECENT DEVELOPMENTS

United States 24

RAW MATERIALS

Solution Mining of Uranium, Part 2 27

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 36
Historical Exchange Values and Transaction Values 37
Historical Conversion Values and UF_6 Values 38
Graph of World Uranium Production 39
US Uranium Marketing Activities Statistics 40
Volume and Price of Uranium Deliveries to the European Community 41

GOVERNMENT STATISTICS

Australia 42
Canada 43
South Africa 44
United States 45

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd.

ISSN 0742-4582

NUEXCO

To Our Readers

Nuexco is pleased to announce that James G. Munro has joined Nuexco as our representative in Australia. For the 15 years prior to his retirement in December 1985, Jim was associated with Western Mining Corporation Ltd. of Melbourne, where he was Manager, Minerals Marketing Research & Development and was active in uranium marketing, research, and fuel cycle studies. His association with the uranium industry dates back to 1953 when he was a Plant Superintendent at Australia's first commercial uranium project at Rum Jungle in the Northern Territory. Jim is a metallurgical engineer and a graduate of the University of Melbourne. Jim may be reached at:

7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823

©NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of February 28, 1987)

The **Exchange Value** is **$16.75** per pound U_3O_8, up $0.10 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,445,000** pounds U_3O_8 equivalent, down 400 thousand pounds since last month. The corresponding figure for **active demand** is **2,310,000** pounds, up 167,000 pounds. The spot and near-term **supply-demand ratio** decreased to **1.5:1**.

The *Current Market Data* section of this Report lists nine natural uranium sales, totaling 2.1 million pounds U_3O_8 equivalent in the near-term. Three of the transactions involved UF_6. US-origin uranium is commanding a premium (relative to the Exchange Value) of $1.00 per pound U_3O_8 (up $0.15) in the form of concentrates, and $2.50 per kilogram U (unchanged) in the form of UF_6.

The **Transaction Value** is **$16.90** per pound U_3O_8, down $0.45 since last month. The calculation extends over a 3-month period and includes 12 transactions involving 2.5 million pounds equivalent U_3O_8. The large drop in the Transaction Value is a result of the removal from the calculation of transactions that occurred in the last quarter of 1986. These transactions averaged approximately $17.35.

The UF_6 Value is **$48.00** per kilogram U in UF_6, up $0.25 since last month. There remains a substantial spread between prices that discretionary UF_6 buyers are willing to pay and those that sellers will accept.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 915 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value rose $0.10 this month to $16.75 per pound U_3O_8. Following the conclusion of several sales at discount prices during February, the availability of low-priced material has subsided. Although much of the demand in both Europe and the USA is still highly discretionary, overall demand has strengthened.

Market activity increased in February, and nine sales of natural uranium, involving more than two million pounds equivalent U_3O_8, are reported. None of the transactions reported during February involved US-origin material. Those sales removed a substantial quantity of demand from the market. Several of the transactions were discretionary purchases motivated by particularly attractive offering terms. Most of the sales reported this month involved European utilities, which are now finding considerable financial advantage in the current weakness of the US dollar, and thus are willing to purchase for inventory on the spot market.

Balancing this reduction in demand, one major buyer entered the market seeking up to one million pounds of U_3O_8 for 1987 delivery, and up to four million pounds in the longer term. Another major buyer was in the process of evaluating bids, but did not conclude its purchase by the end of February.

Demand for Canadian-origin uranium remains weak, but the aggressive selling by Canadian producers that had been evident during the past several months has abated. Recent sales by Canadian producers have temporarily reduced pressure to sell additional material.

The US market is still dominated by the deferrals of procurement activity by utilities that are awaiting the outcome of DOE's appeal in the US producers vs. DOE lawsuit. The appeal has been under consideration by the Tenth Circuit Court of Appeals for nearly six months. US producers are still not active in the spot market and have not lowered prices for their material, as they await a decision that they expect will result in significantly higher prices for US-origin uranium. The producers group has recently petitioned the appeals court to expedite the decision. The producers contend that DOE is facilitating origin swaps, the effect of which is to circumvent the original ruling banning enrichment of imported uranium.

The prevailing uncertainty about future availability and use of non-US-origin material in the USA has resulted in an increase in the premium for US-origin concentrates, to $1.00 per pound U_3O_8 (relative to the Exchange Value). During February, the market for origin and location swaps of non-US for US-origin material has become tighter. Virtually all of the demand for US-origin material is being met through origin swaps, rather than through direct sales by US producers. However, those remaining entities holding US-origin material that might be made available for swaps also are increasingly deferring their decisions to swap their material, while awaiting a resolution of DOE's appeal.

Consequently, not only are swaps becoming less available and more costly, public scrutiny by US government agencies and storage facilities, regardless of their degree of legal authority over swap transactions, has effectively increased the complexity and risk involved in swapping origins. In particular, the problems of swapping origins between lots of

©NUEXCO 1987

uranium of different chemical forms have created a situation in which swapped US-origin UF_6 is more readily available than US-origin U_3O_8. The expressed preference by one of the major new buyers for US-origin uranium also has served to increase the premium value of US-origin.

The UF_6 Value increased this month, to $48.00 per kgU as UF_6. Demand for UF_6 appears somewhat stronger than demand for concentrates, with several buyers in the market for substantial quantities. Potential uranium buyers that are not committed to conversion contracts tend to prefer to purchase in the form of UF_6, therefore the premium for US-origin UF_6 did not increase.

* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported, and the market for loans continues to be essentially dormant. In the event that firm demand for loans emerged, ample supply would likely become available at reasonable loan rates.

* * *

The Conversion Value is unchanged since last month at $1.80. The secondary market for conversion services shows slightly increased activity this month, and one conversion transaction is reported. In Europe, secondary market conversion remains largely uncompetitive, as the weak dollar has made such services more expensive than in the USA or in Canada.

ENRICHED URANIUM AND SWUS

The SWU value is unchanged since last month, remaining at $80.00 per SWU. Three SWU transactions are reported in the *Current Market Data* section of the Report, totaling over 400 thousand SWUs. Included in this total is a small quantity of Soviet origin. Spot sales of Soviet-origin SWUs have increased dramatically over the past several months. However, to conclude sales of Soviet-origin SWUs, sellers have been obliged to offer substantial discounts in order to overcome buyers' reluctance.

The presence of discounted Soviet-origin SWUs has widened the spread of SWU prices in the current market, which tend to reflect origin, quantity, and specifications for enriched product. As with uranium, origin has become an increasingly important consideration in SWU prices. The presence in the market of several potential buyers of substantial quantities of SWUs was balanced by greater availability of SWUs for sale, resulting in little price pressure in either direction. As of the end of the month, two secondary market buyers continued to evaluate offers for large quantities of non-Soviet SWUs.

©NUEXCO 1987

CURRENT MARKET DATA

February 28, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.75**/lb. U_3O_8	3,445	2,310
UF_6 VALUE	**$48.00**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	915	1,000
SWU VALUE 0.3 tails assay; delivery within one year	**$80**/SWU		
LOAN RATE	**3%**/annum	0	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**16.90**	2.5	12	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Feb 28, 1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**	**This Month (Feb 28, 1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**
Australia (dollar)	24.83	25.16	23.97	64.54	65.41	62.31
Belgium (comm. franc)	632.06	615.98	771.68	1,643	1,601	2,006
Canada (dollar)	22.32	22.33	23.98	58.01	58.05	62.35
EEC (ecu)	14.79	14.42	17.39	38.46	37.49	45.21
Finland (markka)	75.86	74.83	86.03	197.22	194.54	223.66
France (franc)	101.70	99.28	116.20	264.40	258.12	302.09
FRG (mark)	30.55	29.75	37.89	79.43	77.35	98.50
Italy (lira)	21,691	21,213	25,668	56,392	55,149	66,731
Japan (yen)	2,564	2,535	3,082	6,666	6,590	8,012
Netherlands (guilder)	34.52	33.57	42.67	89.75	87.27	110.93
South Africa (rand)	34.54	33.98	33.73	89.79	88.34	87.69
Spain (peseta)	2,145	2,122	2,380	5,576	5,517	6,187
Sweden (krona)	107.93	107.28	121.69	280.58	278.91	316.37
Switzerland (franc)	25.73	25.02	32.00	66.89	65.03	83.20
UK (pound)	10.87	10.83	11.58	28.25	28.14	30.11
US (dollar)	16.75	16.65	17.00	43.55	43.29	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Feb 28, 1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**	**This Month (Feb 28,1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**
Australia (dollar)	25.05	26.22	23.54	65.12	68.16	61.21
Belgium (comm. franc)	637.74	641.88	758.06	1,658	1,669	1,971
Canada (dollar)	22.52	23.27	23.56	58.53	60.49	61.25
EEC (ecu)	14.93	15.03	17.08	38.80	39.06	44.41
Finland (markka)	76.54	77.98	84.51	198.99	202.72	219.72
France (franc)	102.61	103.46	114.15	266.77	268.97	296.76
FRG (mark)	30.83	31.00	37.22	80.15	80.60	96.76
Italy (lira)	21,886	22,105	25,215	56,897	57,476	65,554
Japan (yen)	2,587	2,642	3,028	6,725	6,868	7,871
Netherlands (guilder)	34.83	34.98	41.92	90.55	90.94	108.98
South Africa (rand)	34.85	35.41	33.13	90.59	92.05	86.14
Spain (peseta)	2,164	2,211	2,338	5,626	5,749	6,078
Sweden (krona)	108.89	111.79	119.54	283.09	290.63	310.78
Switzerland (franc)	25.96	26.07	31.44	67.49	67.77	81.73
UK (pound)	10.96	11.28	11.38	28.50	29.33	29.58
US (dollar)	16.90	17.35	16.70	43.94	45.11	43.42

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Feb. 27, 1987.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (Feb 28, 1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**	**This Month (Feb 28, 1987)**	**Last Month (Jan 31, 1987)**	**12 Months Ago (Feb 28, 1986)**
Australia (dollar)	2.67	2.72	2.54	5.88	6.00	5.59
Belgium (comm. franc)	67.92	66.59	81.71	149.75	146.81	180.13
Canada (dollar)	2.40	2.41	2.54	5.29	5.32	5.60
EEC (ecu)	1.59	1.56	1.84	3.50	3.44	4.06
Finland (markka)	8.15	8.09	9.11	17.97	17.83	20.08
France (franc)	10.93	10.73	12.30	24.09	23.66	27.12
FRG (mark)	3.28	3.22	4.01	7.24	7.09	8.84
Italy (lira)	2,331	2,293	2,718	5,139	5,056	5,992
Japan (yen)	275.52	274.06	326.32	607.43	604.19	719.42
Netherlands (guilder)	3.71	3.63	4.52	8.18	8.00	9.96
South Africa (rand)	3.71	3.67	3.57	8.18	8.10	7.87
Spain (peseta)	230.50	229.42	252.00	508.17	505.78	555.55
Sweden (krona)	11.60	11.60	12.88	25.57	25.57	28.41
Switzerland (franc)	2.76	2.70	3.39	6.10	5.96	7.47
UK (pound)	1.17	1.17	1.23	2.57	2.58	2.70
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Feb 28, 1987)**	**UF_6 Value per kg.U in UF_6 This Month (Feb 28, 1987)**	**UF_6 Value per kg.U in UF_6 Last Month (Jan 31, 1987)**
Australia (dollar)	118.57	71.14	72.15
Belgium (comm. franc)	3,019	1,811	1,767
Canada (dollar)	106.58	63.94	64.03
EEC (ecu)	70.66	42.39	41.35
Finland (markka)	362.32	217.39	214.60
France (franc)	485.73	291.43	284.73
FRG (mark)	145.93	87.55	85.32
Italy (lira)	103,600	62,160	60,836
Japan (yen)	12,246	7,347	7,270
Netherlands (guilder)	164.88	98.92	96.27
South Africa (rand)	164.95	98.96	97.44
Spain (peseta)	10,245	6,147	6,086
Sweden (krona)	515.46	309.27	307.66
Switzerland (franc)	122.89	73.73	71.73
UK (pound)	51.90	31.13	31.04
US (dollar)	80.00	48.00	47.75

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Feb. 27, 1987.

©NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3970	1987	101-300	100	Utility	Trader	
3966	1987	101-300	98	Trader	Utility	UF_6
3964	1987	101-300	104	Producer	Trader	
3962	1987	301-600	102	Producer	Trader	
3961	1987	601-1000	99	Trader	Utility	
3960	1987	less than 50	100	Utility	Trader	
3959	1987	less than 50	109	Trader	Utility	UF_6
3948	1987	101-300	94	Utility	R[5]	
3939	1987	101-300	103	Trader	Utility	UF_6

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.

[3] Price is not normalized to 0.20% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3955	1988	101-300	101	Trader	Utility	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
3967	1988	50-100	106	Trader	Utility	R[5]	
3968	1988	less than 50	90	Trader	Utility	USSR	
3969	1987-88	301-600	101	Trader	Utility	R[5]	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.20 w/o tails assay.

[3] Price is not normalized to 0.20% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335*	420	—	
2740*	250	—	
2893A*	720	—	UF_6
2933	300	300 per year	1988-90
2967	200	—	
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121	500	—	
2263	—	400 per year	1989 on
2781	—	750 per year	1988-95
2996	—	500 per year	1988-90
3129	500	500	
3171	—	200 per year	1988-92
TOTAL:	3,445		
INACTIVE			
2297	100	100 per year	1988-89
2389	75	75 per year	1988-90
2764	260	—	UF_6
3166	25	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981*	—	600 per year	1988-91
3128*	—	100	1989
TOTAL:	510		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2885B, 2975, 2990, 3194.

©NUEXCO 1987

URANIUM DEMAND
(February 28, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Inquiries to Purchase:			
ACTIVE			
2878A*	60	—	U_3O_8 or UF_6
2890*	175	—	
2984*	330	—	U_3O_8 and UF_6
2991	105	—	UF_6
3009	590	—	UF_6
3120*	1,000	1,000 per year	1988-91
3192	50	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500	1989 on
2985	—	675 per year	1992 on
3147	—	200	1988-92
3193*	—	700 per year	1989 on
TOTAL:	2,310		
INACTIVE			
2760	750	750 per year	1988-90
2798*	50	—	
2911*	65		UF_6
2956	350	350	U_3O_8 or UF_6
TOTAL:	1,215		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2995, 3017, 3097, 3158.

©NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF₆) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
2859*	750	750	
2988*	165	—	
TOTAL:	915		
Available for Sale: INACTIVE			
3165*	330	—	
TOTAL:	330		
Inquiries to Purchase: ACTIVE			
3120*	1,000	700	1988-89
TOTAL:	1,000		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

LOAN SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2920	2,000	—	
TOTAL:	4,500		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

No inquiries to borrow are reported this month.

SWU SUPPLY AND DEMAND
(February 28, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571*	55	—	1987
2969	200	—	1987
3156	70	—	1987
3162*	50	—	1987
3213*	205	—	1987
TOTAL:	580		
Inquiries to Purchase:			
ACTIVE			
2878	65	—	1987
2999	150	—	1987
3009	200	—	1987
3043*	10	—	1987
TOTAL:	425		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: None.

©NUEXCO 1987

ANALYSIS AND COMMENTARY

WORLD URANIUM CONSUMPTION FORECAST, 1987-2000

This article summarizes Nuexco's revised uranium consumption forecast for the remainder of this century. A more detailed analysis is presented in Nuexco's Uranium Market Study and Price Forecast.

Introduction

The 1987 edition of Nuexco's Uranium Market Study and Price Forecast shows a fundamentally different uranium consumption forecast, which significantly affects our forecast of future uranium prices. The changes in Nuexco's outlook for consumption have resulted primarily from an altered forecast of plant capacity factors in the period, brought about by unanticipated improvements in reactor operating results in the past three years.

The Uranium Institute recently published its report entitled "The Uranium Market 1986 – 2000", which, among other data, contains the Institute's forecast of nuclear electric generating capacity and the corresponding uranium requirements. The Institute's generating capacity forecast is greater than Nuexco's, but its uranium requirements forecast is lower than Nuexco's. Nuexco has compared the forecasts in order to determine the reasons for the differences. The following analysis illustrates Nuexco's methodology, and examines some of the differences between the two forecasts of uranium consumption.

Nuexco Methodology

The term "consumption", as used by Nuexco, means the amount of natural uranium, in the form of ore concentrates, needed to be delivered to a conversion plant (converting ore concentrates to UF_6) in order to begin preparation of fuel assemblies, on a normal lead time prior to:

— the commercial operation date (COD) of a given reactor if for an initial core, or

— the periodic refueling date if for reload fuel. Nuexco has used a lead time of 24 months prior to COD for the initial core, and 18 months prior to refueling for reloads. Nuexco treats the uranium as being consumed when it enters the chain of fuel preparation operations. Thus, for a reactor starting commercial operation in 1990, the natural uranium for the initial core loading is classified as being consumed in 1988. The amount of uranium is expressed in terms of pounds U_3O_8 equivalent.

Natural uranium consumption is forecast to grow in the reference case from 106 million pounds U_3O_8 in 1985 to 145 million pounds in 2000, an increase of 37 percent over 15 years, corresponding to an average annual compound growth rate of 2.1 percent. In Nuexco's previous Uranium Market Study and Price Forecast (released in January 1985), the reference case consumption forecast for 2000 was 128.4 million pounds. The difference is largely due to the use of higher plant capacity factors in the current forecast. The consumption calculations are based on an average enriching plant tails assay of 0.25 weight-percent (w/o) U_{235} throughout the study period.

Figure 1 shows Nuexco's uranium consumption forecast for the reference growth case. Figure 2 shows a comparison of the reference, low and high growth cases. Tables 1, 2, and 3 list the forecast uranium consumption by region by year for the reference, low growth and high growth cases. In the USA, uranium consumption averages 39.7 million pounds annually during the study period. However, consumption continues to increase in the other three geographic regions in the study. The reference case average growth rate in uranium consumption, for the period 1986 through 2000, for each region is as follows:

	Average Growth Rate, 1986 — 2000	
Region	**Thousands of Pounds U_3O_8 per Year**	**Compound Growth Rate, Percent per Year**
USA	291	0.8
Europe	1,017	1.8
Far East	1,010	4.8
Other	223	2.8
WORLD	2,541	2.1

The Far East shows the largest growth rate, in percent per year, of the four regions studied. These forecasts of uranium consumption utilize Nuexco's latest computational procedures and data, as further described below.

Principal Controlling Variables Affecting Consumption

Nuexco examines five principal variables affecting uranium consumption. They are listed as follows, and each are described more fully in succeeding paragraphs.

1. Nuclear electric generating capacity in operation, and annual additions.

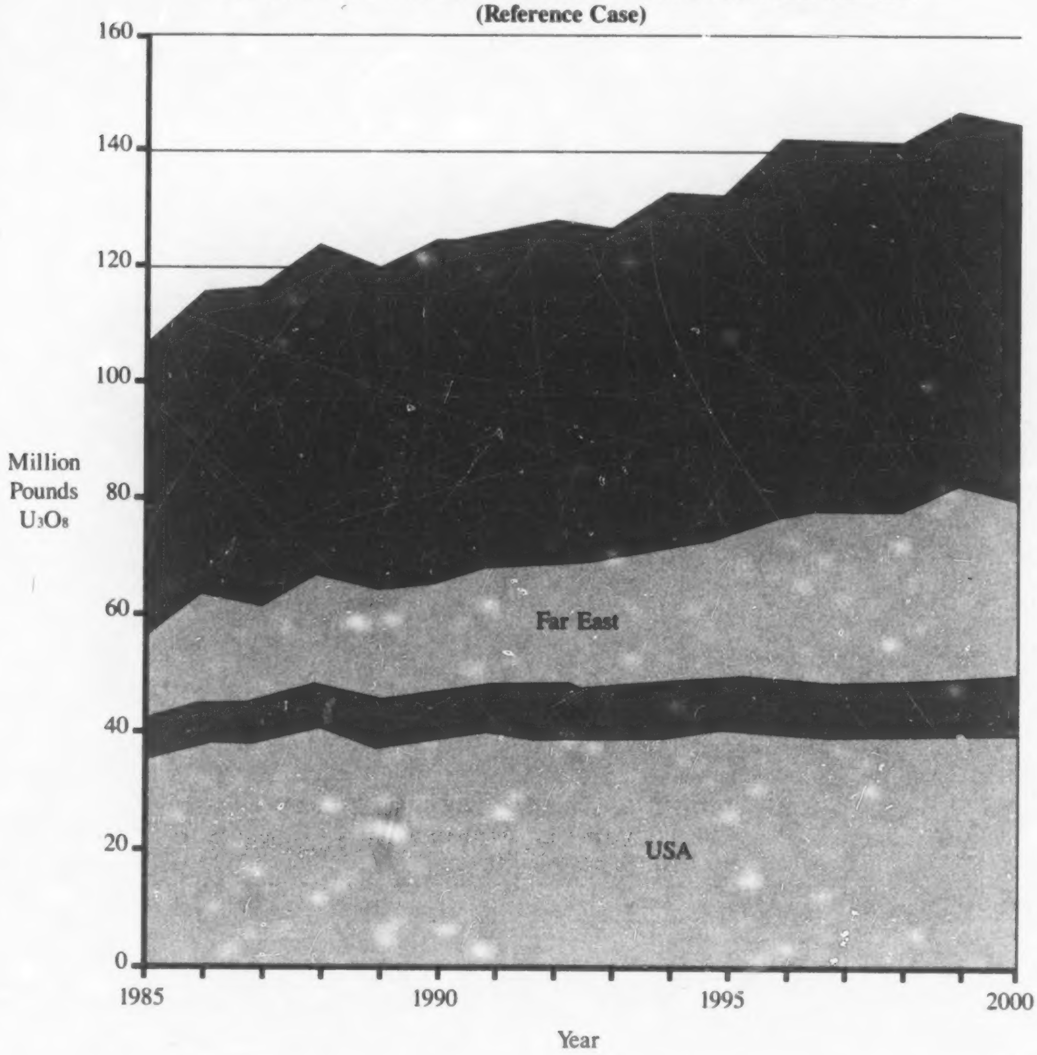
2. Nuclear plant characteristics, including projected operating life, core loading, and thermal efficiency.

3. Plant operating characteristics, such as the capacity factor and the cycle length between refuelings.

©NUEXCO 1987

Figure 1

FORECAST OF WORLD URANIUM CONSUMPTION BY REGION
(Reference Case)



©NUEXCO 1987

TABLE 1A

WORLD URANIUM CONSUMPTION FORECAST[1]
Reference Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	38.3	38.9	41.3	38.0	39.2	40.3	39.0	39.4
Europe[2]	51.2	54.0	56.0	54.2	58.3	56.4	58.8	55.8
Far East[3]	19.2	16.1	19.4	19.4	18.7	20.7	20.7	22.5
Other Nations[4]	6.8	7.1	7.0	7.8	7.9	7.9	9.4	8.4
TOTAL[5]	115	116	124	119	124	125	128	126

TABLE 2A

WORLD URANIUM CONSUMPTION FORECAST[1]
Low Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	37.2	39.0	35.9	37.4	39.4	37.4	37.7	37.7
Europe[2]	48.5	50.1	49.8	52.7	54.1	52.7	54.4	55.6
Far East[3]	18.8	15.6	16.9	18.8	18.8	17.5	22.0	19.8
Other Nations[4]	6.5	6.4	6.6	6.9	6.9	6.8	7.9	7.8
TOTAL[5]	111	111	109	116	119	114	122	121

TABLE 3A

WORLD URANIUM CONSUMPTION FORECAST[1]
High Case
(Millions of Pounds U_3O_8)

	1986	1987	1988	1989	1990	1991	1992	1993
United States	39.2	39.5	39.0	40.5	39.2	39.5	39.4	42.0
Europe[2]	51.3	56.0	57.3	57.0	57.6	58.1	58.6	61.7
Far East[3]	16.8	19.2	17.2	18.7	21.9	20.3	22.3	25.3
Other Nations[4]	7.6	7.5	8.1	8.0	9.4	9.2	8.7	9.1
TOTAL[5]	115	122	122	124	128	127	129	138

[1] Consumption is based on computed quantities of U_3O_8 used to fabricate fuel for loading and reloading reactors operating, under construction, on order or forecasted as of 12/31/86. Compiled and computed on a reactor-by-reactor basis; quantities for each reactor are based on specific core characteristics, 0.25% enriching tails assay, no recycling, 24-month lead time for first cores and 18-month lead time for reloads.

[2] Austria, Belgium, Finland (Two Swedish-supplied plants), France, Germany (FRG), Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Yugoslavia.

[3] China (PRC), Japan, South Korea, Philippines, Taiwan.

[4] Argentina, Brazil, Canada, Egypt, India, Iran, Iraq, Israel, Libya, Mexico, Pakistan, South Africa and Turkey.

[5] Includes only those nations that participate in the commercial uranium market. Nations which are excluded are Bulgaria, Cuba, Czechoslovakia, Germany (GDR), Finland (two USSR-supplied plants), Hungary, Poland, Rumania, and the USSR. Columns may not add, due to rounding.

©NUEXCO 1987

TABLE 1B

WORLD URANIUM CONSUMPTION FORECAST[1]
Reference Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	39.4	40.7	40.5	39.6	40.1	40.1	40.1
Europe[2]	60.8	58.3	64.4	62.1	62.5	63.7	64.5
Far East[3]	22.7	24.2	27.7	30.0	29.3	32.9	30.2
Other Nations[4]	9.8	8.9	9.0	9.1	9.3	9.7	9.8
TOTAL[5]	133	132	142	141	141	146	145

TABLE 2B

WORLD URANIUM CONSUMPTION FORECAST[1]
Low Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	37.7	37.7	37.6	37.5	37.5	37.5	37.5
Europe[2]	56.0	56.1	57.3	55.8	59.1	58.2	58.7
Far East[3]	21.2	22.6	22.9	24.9	23.8	25.7	29.8
Other Nations[4]	8.6	8.3	9.6	8.2	8.8	8.7	8.6
TOTAL[5]	123	125	127	126	129	130	135

TABLE 3B

WORLD URANIUM CONSUMPTION FORECAST[1]
High Case
(Millions of Pounds U_3O_8)

	1994	1995	1996	1997	1998	1999	2000
United States	41.9	40.3	41.1	41.0	41.0	41.0	41.0
Europe[2]	60.7	65.8	64.1	66.3	66.7	65.4	70.0
Far East[3]	23.8	29.3	31.3	32.8	34.8	34.6	33.5
Other Nations[4]	8.9	9.2	9.2	10.1	9.4	10.1	10.3
TOTAL[5]	185	145	146	150	152	151	155

---

[1] Consumption is based on computed quantities of U_3O_8 used to fabricate fuel for loading and reloading reactors operating, under construction, on order or forecasted as of 12/31/86. Compiled and computed on a reactor-by-reactor basis; quantities for each reactor are based on specific core characteristics, 0.25% enriching tails assay, no recycling, 24-month lead time for first cores and 18-month lead time for reloads.

[2] Austria, Belgium, Finland (Two Swedish-supplied plants), France, Germany (FRG), Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom, and Yugoslavia.

[3] China (PRC), Japan, South Korea, Philippines, Taiwan.

[4] Argentina, Brazil, Canada, Egypt, India, Iran, Iraq, Israel, Libya, Mexico, Pakistan, South Africa and Turkey.

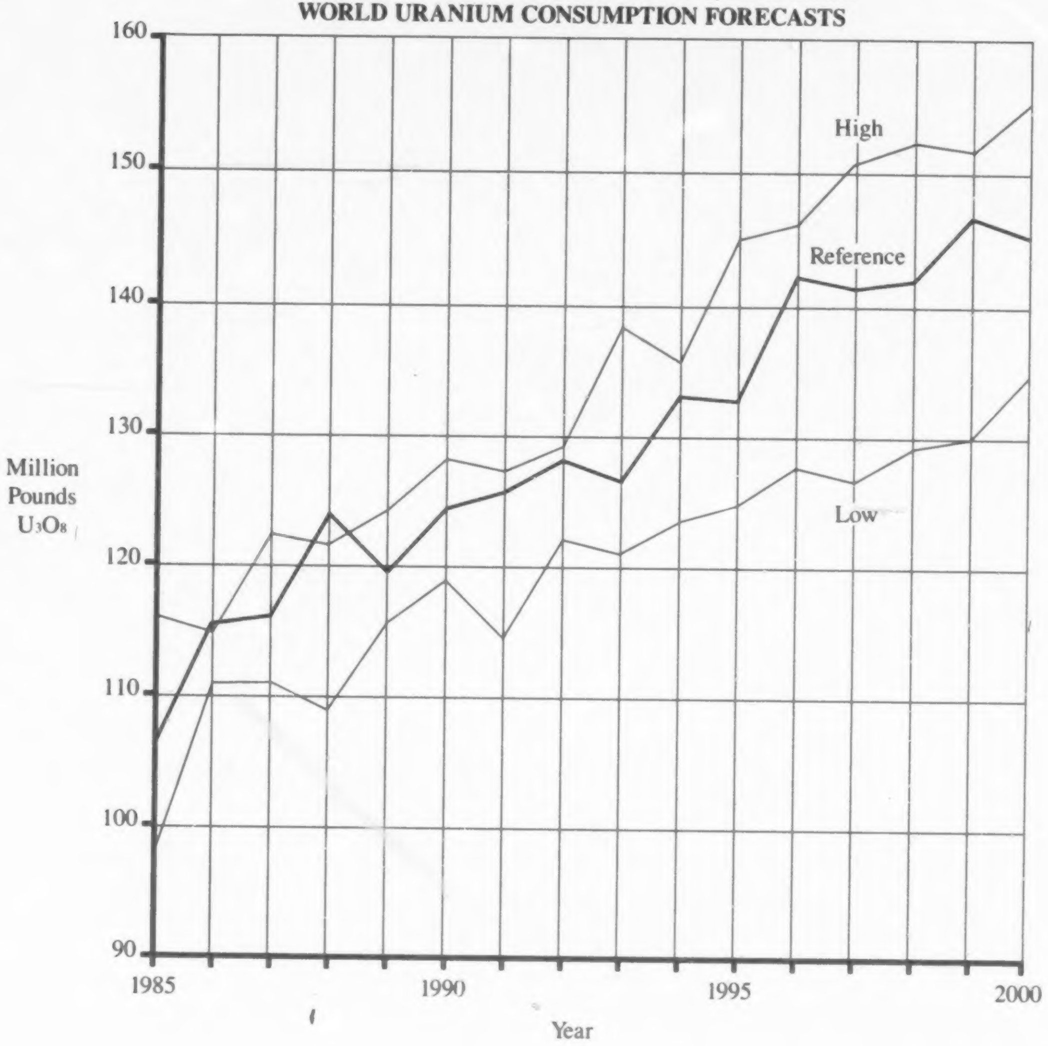
[5] Includes only those nations that participate in the commercial uranium market. Nations which are excluded are Bulgaria, Cuba, Czechoslovakia, Germany (GDR), Finland (two USSR-supplied plants), Hungary, Poland, Rumania, and the USSR. Columns may not add, due to rounding.

©NUEXCO 1987

ANALYSIS & COMMENTARY

Figure 2

COMPARISON OF LOW, REFERENCE, AND HIGH WORLD URANIUM CONSUMPTION FORECASTS



©NUEXCO 1987

4. Nuclear fuel characteristics, such as fuel design, initial core enrichment, and reload fuel enrichment.

5. Fuel cycle characteristics, including the enrichment tails assay, the recycle of uranium and plutonium, fuel preparation lead times, and processing losses.

1. *Electric Generating Capacity and Annual Additions.* The amount of uranium needed for reload fuel varies with installed capacity, and the amount needed for initial core loadings varies with additions to generating capacity.

2. *Plant Design Characteristics.*

— Plant Operating Life – Nuexco normally uses a 35-year operating life (from commercial operation date) for all plants in the forecast, unless a different lifetime is scheduled. Expected retirements are deducted from new plant additions in arriving at net installed capacity.

— Core Loading – Nuexco uses core loadings characteristic of each type of plant. The specific power (MWe/MTU) appropriate to each type of reactor is used in this calculation, so as to relate the size of the core loading to the reactor power rating.

— Thermal Efficiency – Nuexco uses net thermal efficiencies (MWe/MWt) characteristic of each reactor type. These values are typical of each of the stated classes of reactors.

Reactor Type	**Net Thermal Efficiency (percent)**
PWR	32
BWR	32
HWR	30
GCR	36
AGR	41

3. *Plant Operating Characteristics.*

— Capacity factor – This is the ratio of actual electric production to theoretical maximum production if the plant ran at full power 100 percent of the time. In some countries, this is called "plant factor" or "load factor". This variable is extremely important in projecting uranium consumption. In the latest analysis, Nuexco has examined capacity factor data much more rigorously than in the past. Examination of nuclear plant capacity factor data worldwide has led Nuexco to utilize capacity factor values that vary by country and reactor type. BWR and PWR reactors comprise the bulk of the generating capacity, but the other reactor types must also be addressed. As of the end of 1985, world installed nuclear electric generating capacity was distributed by reactor type as follows:

Reactor Type	**Percent of Total**
PWR	59
BWR	29
HWR	6
GCR	4
AGR	2
	100

Nuexco has used plant-by-plant capacity factor data published by *Nuclear Engineering International*[1], in the course of developing a set of capacity factor assumptions. The capacity factors for the nuclear units by country by reactor type were compiled for 1983, 1984, and 1985. These data were then processed to give averages by reactor type by country. The three-year average was viewed as being representative of the present status of capacity factor values for that reactor type in that country. Next, in order to allow for future improvement over the study period, the current three-year average capacity factors were increased by 25 percent of the difference between the current factor and either 85 or 90 percent. The value of 85 percent is viewed as the maximum sustained average annual capacity factor that might be expected from reactors that shut down for refueling, and 90 percent is viewed as the maximum for reactors with on-line refueling. The 25-percent factor is intended to represent the practical capacity factor increase potential over the near future. This methodology yields small additional improvement in capacity factor for those countries or reactor types presently experiencing high capacity factors, and a relatively large expected improvement for countries or reactor types presently experiencing low capacity factors. The resulting capacity factor values, listed by country by reactor type, are listed in Table 4.

There are a number of instances where a given reactor type is either not presently in operation in a given country, or there have been less than three years of operating experience, yet Nuexco still is forecasting the operation of that reactor in that country in the future. For these cases, the capacity factor of that reactor type in that country is assumed to be the *average value* of the projected capacity factor of the same reactor type in countries where there *is* operating data for that reactor. These cases can be identified in the table by the omission of the three-year historical value. These average values are then used in the calculation of uranium consumption. On a weighted basis of generating capacity as of the end of 1985, these individual capacity factors yield a world weighted average capacity factor of 71 percent. The capacity factors used by Nuexco in this forecast are substantially greater than those used in the 1985 Market Study, thus causing a substantial increase in projected uranium requirements.

---

[1] ISSN #0029-5507.

Figure 3 shows the cumulative frequency distribution of reactor capacity factors for the world for 1985, using data from Table 5. There are 253 reactors in this sample. Half of the reactors experienced a capacity factor in 1985 of 72.8 percent or greater. However, due to the skewed distribution, the average capacity factor in 1985 is 67.0 percent. During the past three years, the average world reactor capacity factor has been trending upward as illustrated below.

Year	**Average Capacity Factor (Percent)**
1983	62.1
1984	64.9
1985	67.0
Three Year Average	64.7

— Cycle Length – There is a substantial trend toward longer operating cycles between refuelings. This is usually accompanied by the use of greater fuel burnups. The incentive for longer operating cycles is that minimizing downtime for refuelings leads to better capacity factors. Increases in cycle length generally result in a higher fuel cost, which is usually more than offset by a reduction in cost of replacement energy when the plant is down for refueling. Most US reactors are expected to be on 18 month or longer cycles by the early 1990s. Conversion to longer cycles, accompanied by the use of greater fuel burnup, results in the uranium consumption per unit of energy production remaining approximately constant. However, there is an increase in the inventory of equivalent natural uranium in the reactor, and this is reflected in an increase in uranium consumption as the transition occurs.

The Nuexco uranium consumption calculations are based on cycle lengths planned for each reactor. However, the consumption results are presented on an annualized basis, thereby smoothing the consumption projection curves.

Table 4

CAPACITY FACTORS USED IN CONSUMPTION CALCULATIONS

Country	**Reactor Type**	**Average Capacity Factor over the past 3 Years[1] (Percent)**	**Future Improvement[2] (Percent)**	**Projected Capacity Factor[2] (Percent)**
Argentina	HWR	63.9	6.5	70
Belgium	PWR	81.7	0.8	83
Brazil	PWR	30.1	13.7	44
Canada	HWR	72.1	4.5	77
Egypt	PWR	—	—	68
Finland	BWR	87.8	0	85
France	GCR	39.6	12.6	52
	PWR	71.6	3.4	75
	FBR	60.7	6.1	67
FR Germany	BWR	73.2	3.0	76
	PWR	81.9	0.8	83
	HWR	—	—	70
	AGR	—	—	63
	FBR	—	—	52

[1] Source: *Nuclear Engineering International.*

[2] Nuexco data.

©NUEXCO 1987

Table 4 (continued)

CAPACITY FACTORS USED IN CONSUMPTION CALCULATIONS

Country	Reactor Type	Average Capacity Factor over the past 3 Years[1] (Percent)	Future Improvement[2] (Percent)	Projected Capacity Factor[2] (Percent)
India	BWR	51.6	8.4	60
	HWR	32.9	14.3	47
Italy	BWR	57.6	6.8	64
	GCR	64.4	6.4	71
	PWR	43.1	10.5	54
	HWR			70
Japan	BWR	70.8	3.6	74
	GCR	64.1	6.4	71
	HWR	65.7	6.1	72
	PWR	72.2	3.2	75
	FBR	—	—	52
Mexico	BWR	—	—	73
Netherlands	PWR	79.2	1.4	81
Pakistan	PWR	—	—	68
	HWR	—	—	70
South Africa	PWR	49.8	8.8	59
South Korea	HWR	80.8	2.3	83
	PWR	64.4	5.2	70
Spain	BWR	65.2	5.0	70
	GCR	68.6	5.4	74
	PWR	49.0	9.0	58
Sweden	BWR	76.1	2.2	78
	PWR	59.2	6.4	66
Switzerland	BWR	88.7	0	85
	PWR	87.4	0	85
Taiwan	BWR	73.4	2.9	76
	PWR	39.1	11.5	51
Turkey	HWR	—	—	70
United Kingdom	AGR	54.1	9.0	63
	GCR	64.0	6.5	71
	FBR	21.0	16.0	37
	HWR	—	—	70
	PWR	—	—	68
USA	BWR	52.8	8.0	61
	Graphite	45.2	10.0	55
	GCR	10.3	18.7	29
	PWR	61.3	5.9	67
Yugoslavia	PWR	71.0	3.5	74

[1] Source: *Nuclear Engineering International.*

[2] Nuexco data.

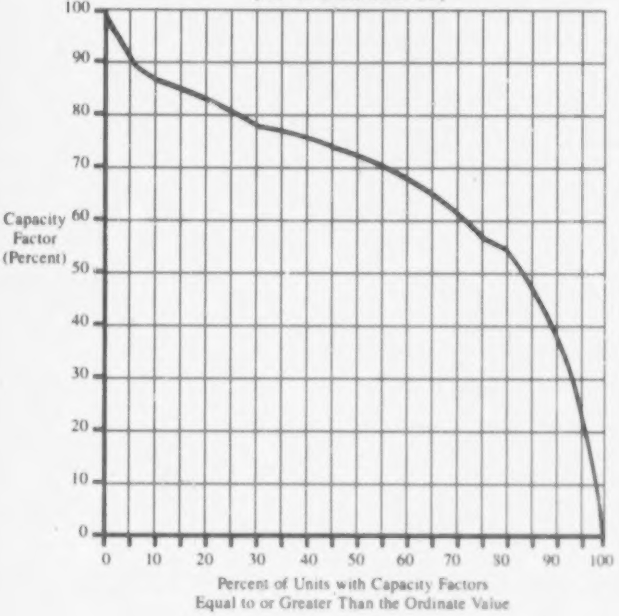
©NUEXCO 1987

NUEXCO

ANALYSIS & COMMENTARY

Figure 3

NUCLEAR PLANT CAPACITY FACTORS CUMULATIVE FREQUENCY DISTRIBUTION
Based on 253 Units Worldwide
(As of End of 1985)



4. *Fuel Characteristics.*

— Fuel Design – Improvements continue to be made in the design of fuel assemblies, many of which improve the utilization of uranium. These will undoubtedly continue, but at a diminishing rate.

— Initial Core Enrichment – In most reactors, the owner may select low, medium or high enrichment initial core designs. This choice affects the length of the first operating cycle and the size and enrichment of the first several reloads. The Nuexco data are weighted toward use of a mid-range enrichment.

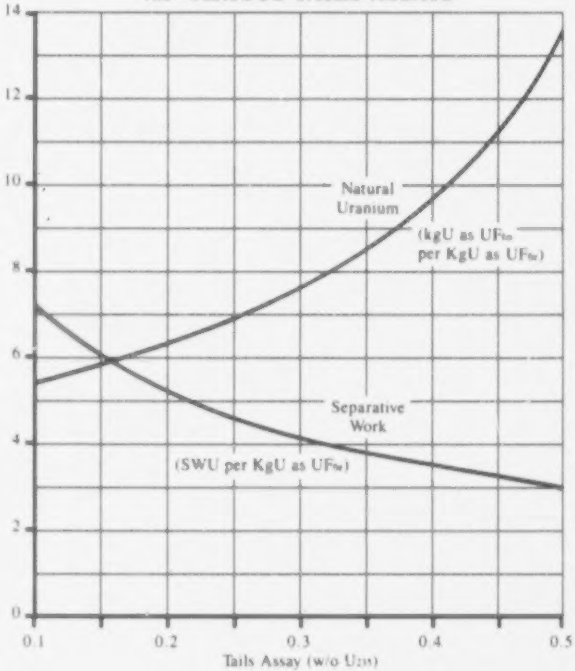
— Reload Fuel Enrichment – As previously noted, there is a tendency toward higher burnups, together with extended duration fuel cycles. The net change in natural uranium consumption between low burnup/short cycles and high burnup/long cycles is small.

5. *Fuel Cycle Characteristics.*

— Enrichment Tails Assay – The companies providing enrichment services offer the customer various choices in specifying the tails assay to be used in the transaction. The tails assay affects the relative amounts of separative work versus natural uranium feed required to produce a given amount of enriched uranium. Consider a product enrichment of 3.4 w/o U_{235} in total uranium. For a tails assay of 0.2 w/o U_{235}, 5.191 kg of separative work units (SWU) and 6.262 kgU as natural UF_6 are required to produce one kilogram of product, whereas at a tails assay of 0.3 w/o, 4.154 kg of SWU and 7.543 kgU as UF_6 are required. Figure 4 shows the uranium and SWU required to produce one kilogram of enriched uranium at a product enrichment of 3.4 w/o, over a tails assay range from 0.1 w/o to 0.5 w/o.

Figure 4

NATURAL URANIUM AND SWU REQUIRED TO PRODUCE ONE KILOGRAM OF 3.4% EUP AT VARIOUS TAILS ASSAYS

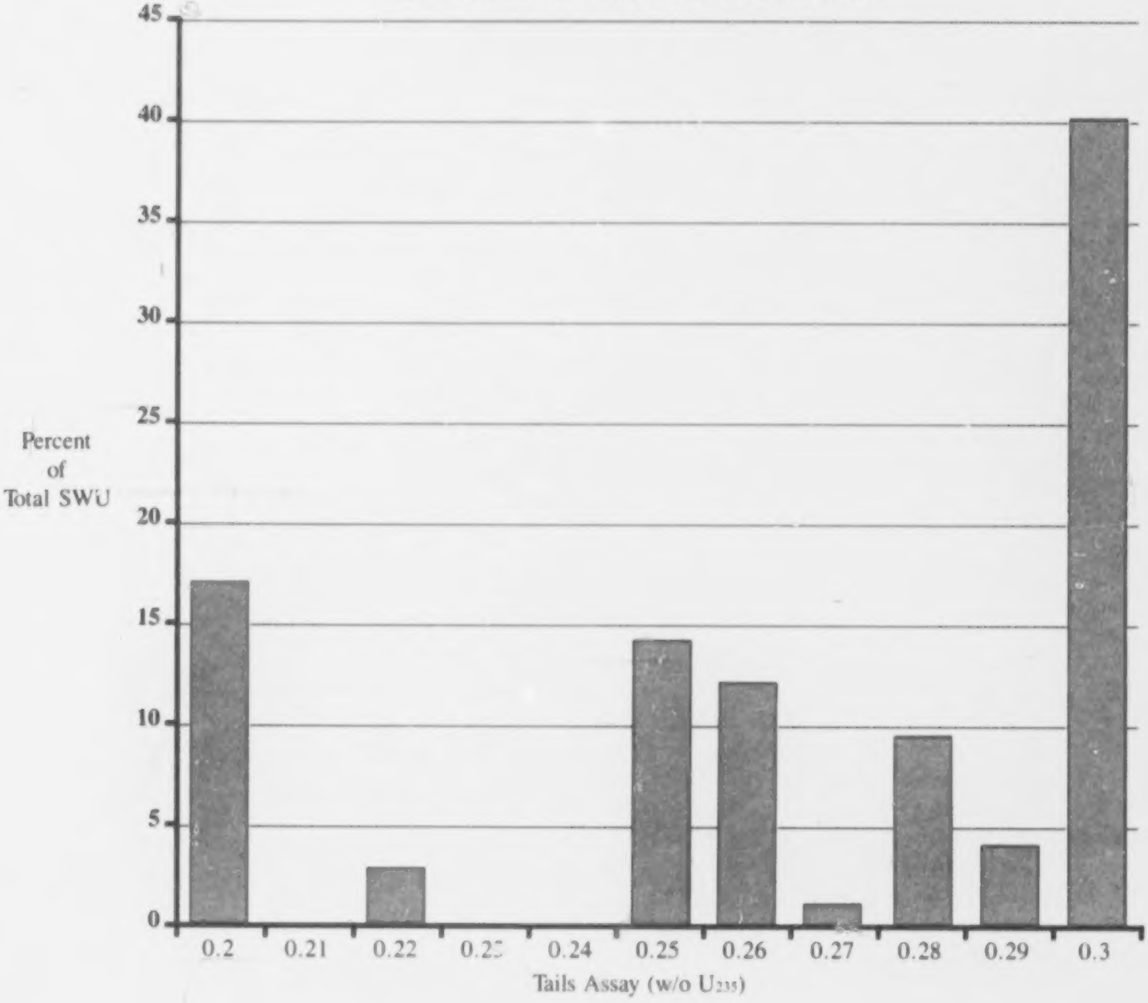


Providing enrichment customers the right to set the tails assay enables the customer to optimize its costs of enriched uranium, depending on SWU and uranium costs. DOE agreed to waive its announced surcharge on the use of tails assays other than the standard value (currently 0.2 w/o) for enrichment customers that take 100 percent of their SWU requirements from DOE. Figure 5 indicates the tails assays

© NUEXCO 1987

Figure 5

ENRICHMENT TAILS ASSAY SPECIFIED BY DOE CUSTOMERS FOR FY87 DELIVERIES



© NUEXCO 1987

currently utilized by DOE customers in FY1987. The ordinate is the proportion of SWUs sold at the stated transaction tails assay to all SWUs sold at all tails assays, expressed as a percentage. The weighted average tails assay in that year is 0.27 w/o. Note that the most frequent assay selected is 0.3 w/o.

In the above example, the use of 0.3 w/o tails versus 0.2 w/o reduces uranium consumption by 20 percent. Thus, the transaction tails assay is also one of the most important variables affecting uranium consumption.

The optimum tails assay is strongly affected by the relative costs of separative work and natural uranium. Nuexco has used a tails assay of 0.25 w/o U_{235} in calculating uranium consumption over the study period. If the laser enriching process can be utilized near the end of the study period, and if its costs are within the range predicted by DOE, then the enrichment tails assay could become much lower, even below 0.2 w/o. Figure 6 shows the cost of one kilogram of uranium enriched to 3.4 w/o for tails assays in the range of 0.1 to 0.5 w/o, a natural uranium price of \$80/Kg as UF_6, and SWU prices of between \$50 and \$125 per SWU. These curves are valid if there are no surcharges for altering the tails assay. The minimum of each curve shows the tails assay that yields minimum product cost. For \$100 SWU and \$80 per kgU as UF_6, the optimum tails assay is 0.251 w/o.

— Recycle of Uranium and Plutonium – A number of countries are or will be operating chemical reprocessing plants for the separation of uranium, plutonium, and fission products. Later, the recovered uranium and plutonium can be recycled into reactors, thereby reducing the need for fresh natural uranium and separative work. However, on a worldwide basis, the reduction in natural uranium consumption during the study period is small, especially if recovered plutonium is chiefly utilized in breeder reactor programs. Therefore, Nuexco has not explicitly incorporated recycle into the consumption calculations. It is, however, factored into Nuexco's estimates of unfilled requirements.

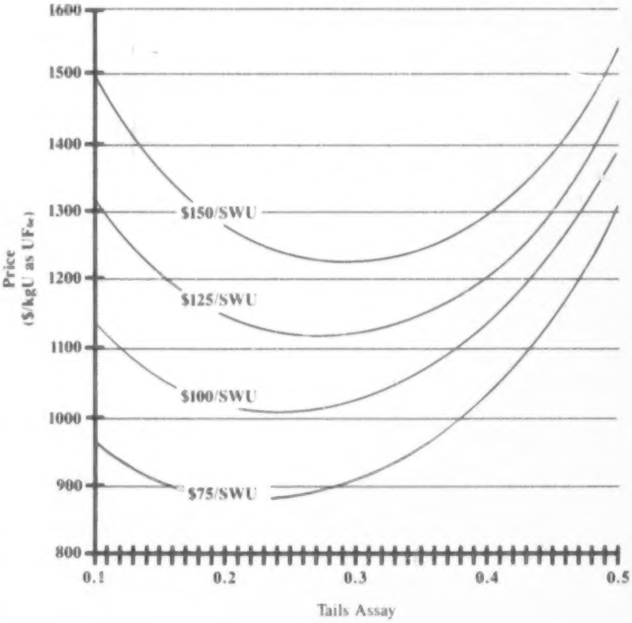
— Fuel Preparation Lead Times – As described earlier, natural uranium is needed 18 months to two years prior to the time that the fuel assemblies to be produced from such material are to be utilized in a reactor. These lead times are not likely to change in any major way such as to affect the consumption calculation results.

— Processing Losses – The consumption calculations are based on a yield during conversion of 99.5 percent and an allowance of one percent for extra material to be provided to the fuel fabricator.

Thus, due mainly to Nuexco's emphasis on growing capacity factors, the latest forecast of world uranium consumption shows a marked increase over the previous Nuexco forecast of January 1985. The current reference case projection also is approximately 12 percent higher than the Uranium Institute's latest forecast.

Figure 6

COST OF ONE KGU ENRICHED TO 3.4%
AT VARYING TAILS ASSAYS
Zero Surcharge Basis
(Assumes \$80/kgU as UF_6 feed)



Comparison of Nuexco and Uranium Institute Forecasts

The Uranium Institute's recently published report contains the Institute's forecast of nuclear electric generating capacity and the corresponding uranium demand. The Institute's nuclear generating capacity forecast is greater than Nuexco's and its uranium demand forecast is lower than Nuexco's. Some of the reasons for these differences are outlined below.

The Nuexco forecast does not incorporate the effect of recycle of recovered products from the reprocessing of spent fuel. Nuexco's forecasts of the world uranium supply-demand balance treat recycle as a source of added supply rather than as a reduction of demand. Hence, the comparison between the Institute's forecast and Nuexco's, shown in the following table, is based on the respective forecasts *excluding* the reduction due to recycle.

©NUEXCO 1987

COMPARISON OF FORECASTS

Year	Uranium Institute[1]		Nuexco	
	Generating Capacity (GWe net)	Uranium Demand (Million Pounds U_3O_8)	Generating Capacity (GWe net)	Uranium Demand (Million Pounds U_3O_8)
1986	228.9	110.0	228.4	115.4
1990	291.7	115.7	283.1	124.2
1995	330.5	128.4	308.3	132.0
2000	372.9	136.0	345.9	144.6
Average GWe	311.6		295.9	
Total Uranium Demand		1,852		1,958

[1] SOURCE: *The Uranium Market 1986-2000*. Published by the Supply and Demand Committee of The Uranium Institute, December 1986. ISBN# 0 946 777 08X.

The average installed nuclear electric generating capacity over the study period (assuming a straight line interpolation between 1995 and 2000 for the Uranium Institute's data, since those years are not shown in its report) is determined to be 311.6 GWe (net) by the Institute and 295.9 GWe net by Nuexco, the latter being lower by 5.0 percent.

The total of reactor uranium requirements (Nuexco refers to this as "consumption") over the period (1986 to 2000) is 1,852 million pounds U_3O_8 in the Institute's forecast and 1,958 million pounds U_3O_8 in Nuexco's forecast, the latter being 5.7 percent higher. Adjusting for the five-percent difference in installed capacity makes the Nuexco uranium requirements forecast 11.3 percent greater than the Institute's. Thus, if Nuexco's installed capacity forecast were increased to correspond with the Uranium Institute's forecast, Nuexco's uranium consumption forecast for the period would be increased to about 2,062 million pounds U_3O_8, from 1,852 million pounds (an increase of 11.3 percent).

Nuexco's forecast is based on an enrichment tails assay of 0.25 w/o throughout the period. The Institute uses a declining tails assay, reported as 0.25 w/o in 1985, 0.22 w/o in 1995, an 0.20 w/o in 2000. Assuming straight line interpolation between the reported data points, the weighted average (weighted by uranium demand) tails assay used by the Institute over the period is 0.225 w/o. If Nuexco had used 0.225 w/o tails in its calculations, its uranium demand would have been about 4.4 percent lower. Therefore, if Nuexco's forecast were adjusted for both the capacity and the tails assay differences, it would result in 1,971 million pounds U_3O_8 consumption over the period, compared with 1,852 million for the Institute; Nuexco's figure is still 6.4 percent higher.

A rough comparison of the nuclear plant capacity factors used by the Institute and Nuexco for the projections indicates a close similarity. The Institute uses a single value of the capacity factor for each country (for all reactor types in the country), whereas Nuexco uses a single value for *each reactor type* in each country. This procedure gives Nuexco data a multiplicity of values for each country, therefore making a comparison with the Institute's data difficult. However, it appears that little of the remaining difference is attributable to this potential discrepancy.

Instead, the uranium consumption per unit of electricity produced (in units such as pounds U_3O_8 per MWe-year [net] of electricity production) is apparently responsible for the majority of the remaining 6.4-percent discrepancy. At the start of the study period, the values used by the Institute and Nuexco are very similar. However, the Institute assumes a substantial reduction in the unit consumption rate over the years, whereas Nuexco assumes only a small reduction. For example, the Institute assumes a reduction of 10 percent by 1995 and 20 percent by 2000 for the consumption of uranium per MWe-year of electricity production in France, attributable to more efficient utilization of the fuel (and not due to recycle or other external changes). For other major consuming countries, the Institute uses 15-percent improvement by 1995 for Germany and Japan, and 5 percent by 1995 and 10 percent by 2000 for the USA. Nuexco's assumptions for this type of improvement in fuel utilization are in the range of one to two percent. Thus, the 6.4-percent normalized difference between Nuexco data and the Institute's data is attributed to the Institute's optimism regarding future improvement in fuel utilization in the existing reactor types.

©NUEXCO 1987

RECENT DEVELOPMENTS

UNITED STATES

Market participants continue to await action by the US Tenth Circuit Court of Appeals on DOE's appeal of Judge Carrigan's order in the uranium producers' litigation. The litigation is also of concern to members of Congress. However, many are content to let the Appeals Court dictate a solution, since conflicting interests within Congress are so polarized over how to solve the problems. In the meantime, a number of other nuclear-related issues are drawing attention.

1. A bill clearly intended as retaliation against Canada's UF_6 upgrading policy is under consideration in the House of Representatives. The Trade and International Economic Policy Reform Act of 1987 (H.R. 3), now under review in committee, would impose a tariff of $3.00 per KgU as UF_6 on uranium imports from any country requiring that uranium be upgraded as a condition of export. Should the proposed legislation ultimately become law it could have a large negative impact on Canadian uranium sales to the USA.

2. The Treasury Department still has not issued final regulations for the implementation of the US ban on the importation of South African uranium. The other provisions of the South African sanctions bill went into effect on January 1, 1987 as scheduled, but imports of South African origin uranium in the form of UF_6 or for processing and reexport (transient imports) have continued. Such imports can be expected to continue at least through June 30, based on the rumored six-month grace period, during which the Treasury Department may be waiting for Congressional clarification of the ambiguous language in the Anti-Apartheid Act.

If the grace period began on January 1, and if the Treasury Department issues final regulations by June 30, then imports of South African uranium might cease as of that date, depending on the scope of the regulations. However, an alternate scenario is possible. Although the Treasury Department has acknowledged that the Nuclear Regulatory Commission (NRC) is the agency responsible for licensing uranium imports, the NRC has neither revoked nor suspended any licenses for the importation of South African uranium. Rather, the NRC adopted a policy effective January 1, 1987 requiring holders of general import licenses to apply for a specific license to import South African uranium. The NRC also "requested" holders of valid pre-1985 specific import licenses to "refrain from importing any material of South African origin" while its review is underway.

The latest controversy over sanctions developed when the Lawyers Committee for Civil Rights under Law, seven Congressmen, and five other organizations intervened in opposition to eight applications for new specific import licenses that have been filed with the NRC. The same group also petitioned the NRC to revoke eleven specific licenses that had been in effect since before 1985 and which are still valid for transient imports. The intervenors claimed that Section 309 of the sanctions bill bans all chemical forms of uranium imports for domestic use or for enrichment and reexport and that to grant new specific licenses or to honor the old ones would circumvent the purposes of the Act. The Treasury Department had been intending to allow the importation of UF_6 intended for reexport, as opposed to U_3O_8, on the basis of its interpretation of the legislative history of the bill. However, the so-called legislative history on which the Treasury Department had intended to rely is highly controversial. It is supposed to have taken the form of a colloquy, which is sometimes spoken or inserted in the record in written form to record the debate and state the intentions of Congress. It is not clear that any such debate or written colloquy was ever approved officially.

3. The renewal of the Price-Anderson Act, which expires in August 1987, is of utmost concern to utilities. If the Price-Anderson Act is not renewed, there could be a significant adverse impact on the value of a utility's stock, the ability to raise capital, renewal of insurance, bonding, etc. However, a renewal of the Act could bring about as much as a tenfold rise in the amounts for which a utility would be liable. (See the article on the Price-Anderson Act in Report 219, November 1987.)

4. Some form of the "Uranium Revitalization & Tailings Reclamation Act of 1986" probably will be reintroduced by Senator Domenici (R, New Mexico) and others in the Senate. Congressman Richardson (D, New Mexico) and others introduced legislation in the House of Representatives on March 15, 1987 (H.R. 1456) that would, among other things, limit uranium imports to no more than 20 percent of US reactor requirements.

5. The House Interior & Insular Affairs Committee and the Energy & Commerce Committee held hearings on February 10 and 11, 1987, on DOE's 1988 budget request. During the hearings, Congressman Morris K. Udall (D-Arizona), Chairman of the Interior & Insular Affairs Committee, who was a key architect of the Nuclear Waste Policy Act (NWPA),was extremely critical of DOE's handling of the program. Many members expressed skepticism at DOE's ability to carry out the NWPA. The program's Mission Plan amendment that would cancel the second repository was also criticized. (See the NWPA article in Report 221, January 1987, and the update in this month's Report.)

Despite the admittedly urgent nature of the complex issues, it will be very difficult to pass any nuclear fuel cycle legislation during the current session of Congress. The Reagan

©NUEXCO 1987

Administration is opposed to import restrictions and to any write-off of DOE's purported $7.5 billion debt below $3.4 billion. Spearheaded by Senator Domenici, the Senate Energy & Natural Resources Committee supports a position that would establish the debt at approximately $300 million. Conversely, the House Energy & Commerce Committee wants $7.5 billion of debt recovered.

The view of some in the government is that Congress originally intended to provide the uranium industry with needed protection, and that the industry is now entitled to the import relief embodied in the Atomic Energy Act [Section 161v (42 U.S.C. 2201v)]. If legislation is introduced to repeal Section 161v of the Atomic Energy Act, it will face determined opposition from western states Congressmen. Due to the nature of the political process, such an action could jeopardize other nuclear-related legislation, such as the renewal of the Price-Anderson Act and any potential fix for the Nuclear Waste Policy Act.

* * *

This article is an update of a detailed article on the Nuclear Waste Policy Act of 1982, which appeared in Report 221, January 1987.

In late January, the Department of Energy (DOE) sent to Congress a proposal that officially postponed the date on which DOE expects to be able to receive high-level waste materials into the first repository specified under the Nuclear Waste Policy Act of 1982 (NWPA). In addition, the proposal postponed the date expected for opening of a Monitored Retrievable Storage (MRS) facility, assuming one is authorized by Congress, and it reaffirmed the indefinite postponement of the siting process for the second repository specified under the NWPA.

The recent announcements came in a revision to DOE's Mission Plan, a document outlining the Department's direction in implementing the NWPA. Postponing the completion date of the first repository sets back the timetable to 2003, five years later than the 1998 date originally mandated under the NWPA. The shift in schedule for the MRS, which has yet to be officially authorized by Congress, delays by two years the expected date for taking spent fuel, to 1998.

The postponements are not a surprise. In Congress, critics of DOE's handling of the repository program have used the occasion to question again the legality and political neutrality behind DOE's making such plans without Congressional authorization. Given the many legal obstacles blocking DOE's efforts to find potential sites for the repository, and the intense controversy generated by nearly every step of the process, the ability of DOE to complete a repository by the mandated time had for some time been seriously questioned.

Under the *current* Mission Plan schedule, site characterization, requiring exploratory shaft construction, on the volcanic tuff and basalt sites (in Nevada and Washington) would have begun in the fall of 1986. Construction at the salt formation site (in Texas) would have begun a year later, in late 1987. Now, under the proposed plan, the Washington and Nevada sites would begin the construction phase of site characterization in mid to late-1988, and the Texas site in late 1989. The end of the site characterization phase now would be scheduled for 1992 and 1993. Evaluation of the results of site characterization would take about three years, until the end of 1994, when DOE would recommend one site to the president for approval or disapproval.

Under the proposed schedule, the final site selection report, which would name the single site that DOE recommends to the president from the three candidate sites now being evaluated, would be issued in 1994. Application to the NRC for the license necessary to proceed with construction would take place soon after, in early 1995. DOE's projected schedule then anticipates construction of the repository beginning about three years later, in early 1998. The first operating phase, in which the repository would begin receiving spent fuel from commercial reactors, would start in 2003. By 2005 the second phase would begin, which would allow the repository to start accepting waste from military and defense storage installations.

The MRS selection and siting process, while not as controversial or complicated as the one involving the permanent repositories, also has been stalled by legal obstacles. The postponement of the MRS in the Draft Mission Plan appears to acknowledge that those legal problems will not be as easily solved as seemed to be the case in November 1986, when a federal appeals court ruled in favor of DOE, by dissolving an injunction that prevented DOE from formally submitting an MRS proposal to Congress. In the draft plan, DOE asked that the MRS facility be limited to storage of no more than 15,000 metric tons of commercial spent fuel, and not to allow the MRS to receive any waste until construction authorization of a first repository is made.

If anything, criticism of DOE has intensified since the new Mission Plan was released. The legality of DOE's decision to reschedule the repository program had been the subject of controversy since Secretary Herrington announced, in May 1986, that DOE was effectively stopping progress on the search for a second repository. Under the NWPA, a second repository was no less critical than the first, with a schedule just as precisely fixed by the legislation. Now, as changes in the schedule for the overall program are proposed, the ques-

©NUEXCO 1987

tion again arises of DOE's authority to decide scheduling of the NWPA.

The status of an MRS facility becomes potentially even more important under the revised schedule. Without an MRS facility in operation and receiving spent fuel by 1998, the legal contract that DOE has with utilities to accept their spent fuel by 1998 cannot be met. If DOE fails in its obligation to accept the waste, utilities could seriously question the status of the funds they have paid into the Nuclear Waste Fund, and the timetable that DOE and the Congress established for payment of the funds. Without an MRS, there is some doubt whether available near-term storage of spent fuel will not become overburdened, especially if schedules slip again. At present, the quantity of spent fuel stored at reactors almost equals the 15,000 metric ton limit just proposed for the MRS facility. By 2000, that quantity will be considerably greater.

The revised Mission Plan has, most of all, given DOE's critics a new platform to threaten the agency with a comprehensive restructuring of DOE's role in implementing the siting process. The inability to meet the originally legislated schedule, the political polarization caused by the siting process and the impression given by DOE of autocratic behavior, and the widespread loss of credibility in DOE's ability to administer the program, have all contributed to new uncertainties regarding the present and future course of the NWPA repository program. How the problems will be resolved will greatly affect not only the nuclear industry, but also every person in the USA.

©NUEXCO 1987

SOLUTION MINING OF URANIUM, Part 2

Introduction

Solution mining of uranium has undergone a long process of development, during which many geological, technical and regulatory problems have been overcome. Solution mining provided about eleven percent of US uranium production in 1986, and the technology offers potential for a considerably greater share of production in the future. The problems involved in restoring the groundwater aquifers once mining has been completed are now largely known, and the uncertainties that characterized many solution mining projects in the past have diminished. Regulations governing solution mining also have become relatively well established, allowing more realistic estimates for time schedules. Even so, only a few solution mining projects are now in commercial operation in the USA, out of more than forty projects which reached at least the pilot plant stage. Given the advances made in the application of solution mining technology, the main problem facing solution mining in the USA is the depressed state of the industry as a whole.

Background

The first uranium solution mining project of record was started by Utah International in 1961 in an ore deposit at a depth of about 350 feet in the Shirley Basin district of Wyoming. The property had been mined by conventional underground methods starting in 1960. In association with that conventional operation, for the next two years Utah experimented with different well completion techniques, well patterns, and lixiviants (the solutions used to dissolve the uranium). Finally, mining began in 1963 using "four-spot" well patterns — one recovery well placed downstream from three injection wells. Ground water flow moved the sulfuric acid lixiviant into the low-pressure area created by pumping the production well. The project operated with some success, under the Atomic Energy Commission (AEC) buying program, until 1969 when it was converted to open-pit mining.

By 1972, four pilot solution mining projects had been started in the South Texas district. The rising price for uranium stimulated interest in the technology and by 1976 nine additional pilot projects were active in Wyoming and Texas. By 1983, when mining activity began to decline drastically, 48 initial pilot projects had been started, eventually leading to the development of 21 commercial operations. The early research and development efforts established a new and efficient in situ leach technology that was generally compatible with environmental requirements. Recovery increased from original levels of about 20 percent of the uranium contained in the formation to over 80 percent in some cases. Application of solution mining technology also proved to be considerably less complicated than for conventional projects. Most equipment is readily available without special design or manufacturing; furthermore, plant and subsurface operations require only low pressures, low temperatures, and low concentrations of chemicals. The foregoing factors contribute directly to improved employee safety and health, and lower operating costs.

Many of the current generation of solution mining projects are operated by small companies whose primary business activity is uranium mining. In this type of company, many key employees have expertise in more than one area, which greatly reduces the number of employees required. Some companies have been able to minimize exploration and research and development costs because of their operating experience and innovative techniques, allowing them to remain competitive in the current market.

Current Projects

There are currently eleven active commercial or R & D (pilot) solution mining projects in the USA, down from a total of 48 in 1983 (see Table 5 for a list of major projects). Seven of the eleven are located in Texas where 1986 output was approximately 1.5 million pounds U_3O_8. Of these, however, only one project is operating at near capacity — the Mt. Lucas project of Everest Minerals Corp., in Live Oak county (Figures 7, 8). Everest is producing at an annual rate of over 500,000 pounds from a 3 million pound reserve discovered in the Goliad sand/conglomerate formation. The project's first wellfields are in the early stage of restoration; production is sustained by new wellfield development. Exploration for additional ore reserves continues in an effort to extend the operating life of the project.

In addition to Mt. Lucas, Everest plans to bring its Tex-1 property, located near Hobson, in Karnes County, Texas into production by late 1987. Approximately 600,000 pounds of uranium are estimated to occur in the Jackson Formation. Pilot testing was successfully completed in 1986 followed by application for a permit to mine. By early 1988, Everest may also undertake production from its Gruy lease, located in Duval County, with a reserve base of about 500,000 pounds U_3O_8, in the Oakville Formation. R & D tests are scheduled for later this year. The annual production rate for both properties remains to be established.

The 50-50 joint venture between US Steel and Niagara Mohawk Uranium Corp. (NMU) currently produces from

©NUEXCO 1987

Figure 7. Satellite ion exchange unit at Everest Minerals' Mt. Lucas Uranium project.

two properties in Live Oak County, Texas. At the Clay West property, the annual production rate for the last nine years has averaged over 750,000 pounds U_3O_8. Restoration is already in progress over much of the deposit and plans call for full restoration to begin in 1987. The project on the Burns lease is presently in the final stage of restoration. This property adjoins Clay West on the southeast, and has averaged over 500,000 pounds production annually during the last nine years; production was less than 100,000 pounds in 1986. US Steel introduced satellite production centers on this lease about eight years ago, a concept that spread throughout the industry as a potential cost-cutting measure.

Intercontinental Energy Corp., (IEC) is shifting activities to the Lamprecht lease from the neighboring Zamzow lease in Live Oak County. The Lamprecht lease was obtained from Wyoming Mineral Corp., under the provision that IEC would mine the remaining ore and eventually complete restoration of the project. IEC has prepared the deposit for full-scale mining to begin this year, continuing for the next two to three years. Restoration will probably begin by 1989 or 1990. The ore is confined to the Oakville Formation.

Mobil Oil Corp. continues to produce from its El Mesquite property located in southern Duval County. The project has been in production since 1979, averaging about 300,000 pounds U_3O_8 per year. However, the production rate is declining as the restoration phase begins in mined-out areas. The ore occurs in the Catahoula Formation.

Uranium Resources, Inc., (URI) is in the final stage of restoration at its Bruni and Benavides properties in southern Duval County. Attention is now focused on the Kingsville Dome property located in Kleberg County. URI has recently acquired full interest in the property, through acquisition of the 50-percent interest controlled by Western Nuclear, Inc. The project was given a permit for mining in late 1986 after a series of public hearings and review by the Texas Department of Health and the Texas Water Commission. URI is preparing to begin mining by late 1987 or early 1988 at a rate as yet undetermined. Reserves have been estimated to exceed 4 million pounds U_3O_8 at an average grade of 0.15 percent uranium. The ore occurs in the Goliad Formation around the flanks of Kingsville Dome, a piercement-type salt (or shale) structure.

Chevron Minerals Corp., is in the last stage of restoration at its Palangana Dome property, Duval County, Texas, which it acquired from Union Carbide. Production in 1986 was less than 50,000 pounds U_3O_8, all of which was extracted during restoration procedures. The ore occurs in the Goliad Formation which has been tilted and faulted along the edge of the dome structure. Union Carbide Corporation attempted to mine the deposit, which has reserves estimated in excess of 3 million pounds U_3O_8, by underground methods in the late 1950s. Mining was terminated due to adverse conditions of ground-caving, excessive amounts of groundwater, and hydrogen sulfide gas. The property was placed on standby for a number of years before solution mining was introduced about 1976. The mine will be fully restored this year, ending over 25 years of interest in the deposit.

In Wyoming, three solution mining projects are located in the Powder River Basin, in Converse and Campbell counties. The joint venture of Everest Mining Corp. and Wold Nuclear (70 percent and 30 percent, respectively), is awaiting approval from the Wyoming Department of Environmental Quality (DEQ), to mine the Highland deposit which was purchased from Exxon Nuclear Company, Inc. in 1983. More recently, the joint venture acquired the adjoining North Morton Ranch property from Tennessee Valley Authority (TVA) consolidating its control of known ore reserves totaling about 30 million pounds U_3O_8, occurring in the lower part of the Wasatch Formation. Pilot testing of the deposit has been in progress for about two years and the joint venture is now ready to start construction of mining facilities and begin mining by early 1988.

The joint venture's pilot program is actually an extension and verification of a similar program conducted by Exxon from 1972 through 1974, and again from 1978 through 1981. The success of the two Exxon programs was an important factor in the decision to acquire the properties. Exxon operated a pilot plant at a rate of 60 gallons per minute with four wellfield patterns. Restoration of the pilot wellfields was in progress at the time of the purchase and is now nearing completion.

Sequoyah Fuels Corp., (Kerr-McGee Corp.) continues to operate a small solution mine on its Bill Smith ore deposit, located to the southwest of the Highland mine. Sequoyah originally mined the deposit by conventional underground methods starting about 1976. The underground mine was placed on standby in 1979 and interest shifted to solution mining of deeper ore zones. The initial pilot test started in 1981 using a flow rate of 100 gpm from a wellfield covering one acre. After a successful period of mining and formation restoration, the test is now in the one-year stability period required by the DEQ. A second pilot test was recently started in another area of the deposit, covering 1.5 acres and using a flow rate of 150 gpm. It is expected to operate for two years before restoration is initiated. The mining has taken place in two different mineralized sand horizons of the Wasatch Formation.

Malapai Resources, Corp., a subsidiary of the AZP Group, Inc., is completing its initial pilot testing on the Christensen Ranch project. The testing, which consisted of two "five-spot" patterns, began in August 1986 and was completed in December 1986 on the Willow Creek deposit. A restoration permit has been issued for the test site and restoration is ready to begin. The company has filed application for a mining permit on the deposit.

Malapai also has an option to purchase the Irigaray deposit and solution mining recovery plant from the Uranium Division of Westinghouse Electric. The plant has an annual capacity of about 500,000 pounds U_3O_8. The property is already fully licensed and could be in production within the short period required for startup preparations. Malapai could fill early delivery requirements from the Irigaray project if necessary. The ore on both deposits occurs in the Wasatch Formation.

In Nebraska, Ferret Exploration Company is operating a solution mining pilot on its Crow Butte property near Chadron. Construction of the pilot plant began in June, 1986 and testing began in August, using two well patterns and a flow rate of 100 gpm. Production from the small pattern (30 foot well spacing) ended in January and preparations for restoration are currently in progress. The larger well pattern (66 foot well spacing) is still in production, maintaining a stable flow and production rate. This wellfield will serve as a basis for expanding to commercial production in the next phase of project development. Project timing is uncertain, but commercial production at an annual rate of 500,000 pounds U_3O_8 by 1989 or 1990 is a possibility. The ore horizon is in the basal Chadron Formation.

Regulatory Requirements

Compliance with regulatory requirements is necessary before pilot testing and commercial operation of a solution

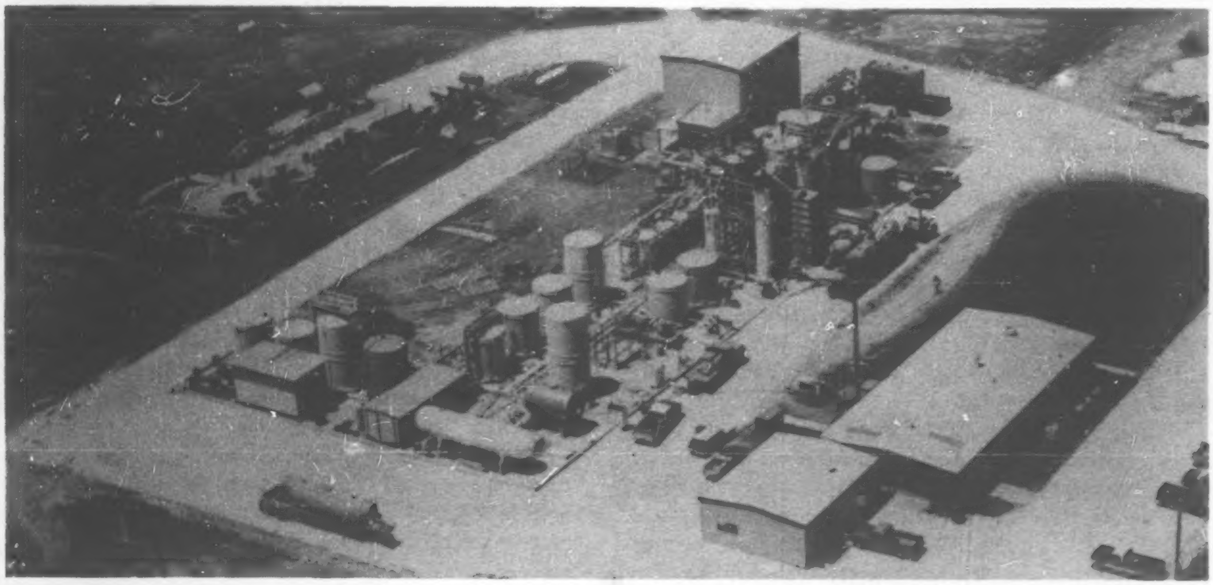


Figure 8. Everest Minerals' central processing plant at Hobson, Texas.

©NUEXCO 1987

mining project can begin. Although all mining requires full compliance with the Safe Drinking Water Act of 1974 and the Federal Water Pollution Control Act, solution mining projects may be subject to even stricter regulations. Regulatory agencies include the Environmental Protection Agency (EPA) with jurisdiction over both water acts, and the Nuclear Regulatory Commission (NRC), with jurisdiction over radioactive materials licensing, and/or various state and county agencies.

Any state which creates its own enforcing agencies and formulates its own requirements for environmental impact, which must be as stringent as federal requirements, is classified as an agreement state. Currently Texas, with two agencies to regulate solution mining, is the only active agreement state. (Colorado and Washington are also agreement states, but have no history of solution mining.) The Texas Department of Health is responsible for issuing and regulating radioactive materials licenses for uranium ores and radioactive by-products (usually limited to medical products). The Texas Water Commission issues and regulates underground injection control (UIC) and aquifer exemption permits (from the Safe Drinking Water Act of 1974), plus a Class I permit for deep well disposal of waste materials, and a National Pollutant Discharge Elimination System (NPDES) permit, for surface discharges that directly affect navigable streams.

A state electing to operate under the jurisdiction of at least one federal agency and one or more state agencies is considered a nonagreement state. Utah, Arizona, Wyoming, Nebraska, and New Mexico are nonagreement states. The permitting policies tend to be less well defined in these states; however, the latter three states do have policies for primary control over UIC and aquifer exemption permitting, plus surface and underground discharge of waste materials.

Each state requires some degree of research and development (pilot testing) prior to giving approval for commercial operations. R & D permits are based on a fairly limited exposure of the surface and subsurface environment to actual operating conditions. The primary function of R & D is to demonstrate aquifer restoration capabilities as they may apply to a commercial-sized operation, although it also enables an operator to establish potential mineral recovery rates.

After the pilot program has proven successful, the operators of a project may file for permission to expand the project into a commercial operation. At this time new applications must also be filed to cover environmental concerns expected under full-scale operation. Again, the requirements for each state differ. An environmental impact statement (EIS) may or may not be required, but usually a detailed hydrological report and a mining license are required. To save time, it is an accepted practice to file the application for a mining license prior to demonstrating final restoration results. Once approved and licensed, a project is be allowed to continue commercial operations under the terms and conditions defined in the final permit applications, for as long as the required environmental controls are properly monitored and maintained.

Actually, solution mining requirements vary considerably according to local geology, hydrology, geochemistry, and surface environment. In Texas, permitting may be accomplished in 12 to 24 months, depending upon the location (by county) of the project. Texas has a broader working knowledge of solution mining than do most states because of its long experience with the oil and gas industry, and more recently, with numerous commercial-scale solution mining projects. In the other states mentioned, the permitting sequence may take three to five years, primarily due to implementation of both federal and state regulations and a lack of regulatory experience in solution mining.

Geological Requirements

As covered in Part 1 of this article (Report 220, December 1986), the geological limitations for effective solution mining of uranium are relatively strict, and formations amenable to this type of mining are found much less frequently than are those suitable for conventional uranium mining operations. One of the primary limiting factors is that the uranium-bearing host formation must be tightly confined within an aquifer, which must exhibit certain characteristics. In particular, the impermeable lower formation containing the aquifer water is necessary to provide control over downward migration of the lixiviant solution. The natural aquifer fluid also is necessary to form the leach solution; to move the leach solution through the mineral deposit; and to provide fluid movement that aids in aquifer restoration.

In addition to aquifer requirements, orebody characteristics also are subject to certain requirements. The uranium contained in the orebody must be in an oxidized state, it must be located a relatively shallow depths, it must exhibit relatively high rates of permeability, it should contain little or no organic matter, and ideally, the ore zone should be positioned near the base of the aquifer.

These geological requirements are mainly found in roll-front deposits within the relatively recent paleochannel sand units in Tertiary formations. The older and deeper uranium-bearing sandstone formations, such as are found in Jurassic sandstones in the Grants mineral belt in New Mexico, tend to be more highly compacted, exhibiting considerably lower

© NUEXCO 1987

formation permeability. In general, greater formation depth usually results in increased exploration, development, production, and operating costs to a project, as well as frequently offering relatively less formation permeability.

Wellfield Procedures

In order to achieve maximum recovery efficiency, the mining and milling facilities of any solution mining project are operated under strict controls. Wellfield technology is complicated, and often is subject to many potential problems associated with hydrology and geochemical reactions. In addition, mechanical malfunctions of wellfield equipment can potentially shut down much of a project's production. Wellfield design and operating characteristics of equipment are, therefore, critical to a successful mining project. In general, much of solution mining technology is taken directly from the petroleum industry. Well completion practices and equipment, plus wellfield management procedures, have become somewhat standardized over the past few years, although they are naturally subject to operator preference.

Both well spacing and type of equipment must be decided in advance of regulatory approval and carried out according to plan; any revisions may be subject to new approval and subsequent delay. All materials going into the well (primarily casing and screens) must be of sufficient quality to endure the mechanical and chemical stresses imposed throughout the life of the project. This requirement applies to injection wells, production wells and monitoring wells, each serving separate functions.

Typically, wells are drilled 4 to 6 inches in diameter, into the impervious formation immediately below the mineralized zone. The drilling is done by conventional rotary equipment, which usually requires the use of a drilling fluid. The fluid, or "mud", normally is made up of ground water from the mineralized zone, with polyanionic cellulose polymers, guar gum, or bentonite additives. The first two are the most suitable since they accomplish everything a drilling mud should, plus they have less tendency to seal off the formation, which can be extremely detrimental to the leaching process.

It is common practice to run geophysical profiles of each well (including exploration holes) following drilling and clean-out procedures. The profiles measure resistivity, natural gamma radiation, and electrical conductivity of the formations, enabling an interpretation of the geology, hydrology, and most importantly, the depth, thickness, and grade of uranium contained in the ore zone. A computer model of the ore body developed from this information can be a valuable tool for developing a mine plan.

After a well is drilled and logged, the next step is to set the casing, which typically is made of polyvinyl chloride (PVC). This type of casing has adequate tensile strength for use to a depth 800 to 900 feet, and it is the lowest-cost material available. Fiberglass and steel casings cost more than PVC but their use may be required for deeper projects. Once the casing is properly aligned in the hole, it is cemented in place, usually from a point immediately above the ore zone to the surface. Cementing prevents the vertical migration of aquifer water and/or lixiviant by sealing off the space between the well wall and the outside of the casing. (Restoration of each well is completed by cementing inside the casing from bottom depth to the surface.) Where the casing goes through the ore zone, it may be slotted or replaced by a fine filter screen in order to allow the lixiviant to circulate freely in or out of the openings. Fine, clean gravel frequently is packed outside the screen liner, especially in the production (recovery) wells. This allows a greatly increased flow-rate of fluids and minimizes lost production time due to sanding or silting of the screen.

Several different well configurations have been commonly used in uranium solution mining, applying the principles of petroleum reservoir engineering. Perhaps the most favored pattern is the "five-spot", with the production well at the center and four injection wells at the corners. A grid of "five-spots" can be effectively placed over the full width and length of an ore deposit. Corner spacing may vary from 50 feet to about 200 feet, depending on formation permeability and characteristics of the aquifer and mineralized zone. Other successful well patterns include the "seven-spot", with six injection wells, and the "staggered line drive", designed to cover the geometric shape of an ore body. Under extreme conditions of mining small ore pods, the "push-pull", or "one-well" technique is used. In such a case, the lixiviant is injected into the ore zone to dissolve the uranium, and is recovered a short time later through the same hole. The one-well technique is commonly used during the pilot testing phase of a project.

Monitor wells are important parts of solution mining projects, both for controlling the production process and for regulatory reasons. These wells may be situated within or outside the ore deposit and are used to monitor the migration of lixiviant both inside and outside the deposit. Taking water samples from monitor wells is an ongoing part of the mining process.

The potential for escape of lixiviant from the wellfield area can be reduced by withdrawing up to ten-percent more ground water than is recirculated. This technique creates a low-pressure zone that allows an influx of native ground water from around the wellfield perimeter, thereby containing

©NUEXCO 1987

the lixiviant. The excess water may then be pumped down deep disposal wells or sent to a lined evaporation pond.

To keep all wells clean and in production requires continuous maintenance, and review of well performance is almost a daily chore. A decrease in the rate of production can indicate any of several problems, each requiring a special procedure to remedy. The more common corrective procedures include:

1. Flushing the well with bleach to kill bacteria;
2. Creating a surge and back flow of fluids to clean plugged wells;
3. Injection of acidic chemicals to remove calcite and iron scale;
4. High-pressure jetting to mechanically clean screens;
5. Removing and reinstalling liners or regravelling the screen packing.

In order to avoid reduced production levels due to inoperative wells, it is desirable to have several wellfields in production at any time.

The Ion Exchange Process

Lixiviant pumped to the surface via the production wells contains leached uranium in solution. The uranium is recovered by passing the solution through an ion exchange system, located either at a satellite facility near the wellfield or at a central recovery plant. Generally, the solution is first transfered from the well to a filtering circuit to remove sand and other debris, although gravel-packed wells may reduce or eliminate the filtering requirement. Next, the solution is passed through ion exchange columns filled with anionic resin beads that continuously attract the uranium from the solution (see Figure 9).

The uranium must be removed from the loaded ion exchange resin using a solution called an eluant. This process (elution) cleans the resin beads of uranium so they can be reused in the ion exchange circuit. In most plants multistage continuous elution is used, although the use of single stage and two stage elution can give satisfactory results, but with less efficiency. Eluants may consist of ammonium carbonate, sodium carbonate, or sodium chloride-sodium carbonate. The latter eluant is often preferred because the chloride ion readily displaces the uranium ion complex, allowing a more complete cleansing of the resin.

Elution is followed by precipitation, beginning with the addition of acid, usually sulfuric acid, to the uranium-rich eluate. The acid removes the anion complex, thereby allowing precipitation by the addition of ammonia, or in some cases hydrogen peroxide or sodium hydroxide. The ammonia/uranium reaction creates ammonium diuranate (ADU), or yellowcake, the most common commercial uranium product.

Molybdenum often is found with uranium in the type of sandstone deposits most suitable to solution mining. If molybdenum is present in the eluate, the addition of hydrogen peroxide may be required to separately precipitate out the uranium. Then, activated carbon columns are used to remove molybdenum from the eluate stream. It can then be disposed of as a solid waste, or collected as a co-product. The exhausted eluate is a saline waste stream that can be reactivated for reuse in the elution column, although this option is often uneconomical. Generally the waste eluate is disposed of by injection into a deep salt water aquifer, or by evaporation.

The uranium concentrate (yellowcake) is washed with fresh water to reduce the chloride content, and either filtered or centrifuged to reduce the moisture content. Next, it passes through a dryer which may consist of a heated rotary spiral, a rotary hearth, or a batch vacuum dryer. The vacuum drying method often has lower operating costs and is environmentally preferred because air emissions are negligible. Some solution mining projects, however, produce a uranium slurry rather than a dry product. The slurry has been acceptable only at the Kerr-McGee conversion facility located at Gore, Oklahoma.

Conclusion

The extraction of uranium by solution mining techniques constitutes the primary advancement in uranium recovery technology during the past 25 years. Originally, the process was developed as an alternative to conventional mining methods, in order to economically exploit lower grade deposits. Although application of the solution mining process is limited geologically to certain types of sandstone deposits, in these settings it can offer definite advantages over most conventional operations, including the potential to turn a nonprofit project into a profitable one. Naturally, each project must be considered individually, weighing the results of engineering and economic studies.

In a technical sense, the advantages of solution mining over conventional uranium mining methods are primarily found in reduced requirements for operating equipment, plant energy, and skilled labor. In addition, this method totally eliminates conventional open pit or underground mining and ore processing, which can represent 60 percent or more of project costs. The main disadvantages are the possibility of lower and slower uranium recovery rates, although this may be a site-specific situation, as well as possibly difficult and expensive project restoration.

© NUEXCO 1987

There are several potential cost benefits to solution mining projects.

1. A smaller land position is usually needed, as well as somewhat more limited exploration requirements (although this may differ for each project due to land/lease status and local geologic characteristics).

2. There is normally a reduced need for orebody development and plant construction.

3. The lead time from initial development to production is often shorter.

4. Smaller capital investment may be required, in particular, avoidance of the high costs associated with large volume reclamation projects that are part of conventional mining and milling methods, including disposal of mine water.

5. Improved safety standards for employees may be achieved through minimized exposure of employees and surrounding population to plant dust and airborne radiation.

Although actual cost reductions will vary according to specific situations, a project with reductions in these areas could achieve significant cost advantages. The main disadvantages are often the limited recovery rates that can affect marketing strategy and project life, and sometimes uncertain restoration costs.

TABLE 5

MAJOR PILOT AND COMMERCIAL SOLUTION MINING PROJECTS IN THE USA

Project/Operator	State	Originally Started	Shut Down	Status
Shirley Basin (Utah International)	Wyoming	1961	1969	closed
Duderstadt Pilot (Cities Service)	Texas	1969	1971	closed
Highland (Exxon, Everest/Wold)	Wyoming	1972	—	operating/restoration
Bruni (Wyoming Minerals)	Texas	1975	1983	restoration
Clay West (US Steel/NMU)	Texas	1975	—	restoration
Nine Mile Lake Pilot (Rocky Mtn. Energy)	Wyoming	1975	1980	closed
Palangana (Union Carbide, Chevron)	Texas	1975	1977	restoration
Burns (US Steel/NMU)	Texas	1976	—	restoration
Lamprecht (Wyoming Minerals, IEC)	Texas	1977	1981	standby
O'Hern (Mobil)	Texas	1977	—	restoration
Pawnee (IEC)	Texas	1977	1979	closed/restoration
Brelum (Mobil)	Texas	1978	1982	closed
NuBeth Pilot (Nuclear Dynamics)	Wyoming	1978	1979	closed
Red Desert Pilot (Union Oil)	Wyoming	1978	1978	closed
Reno Creek Pilot (Rocky Mtn. Energy)	Wyoming	1978	1980	closed
Irigaray (W. Minerals, Westinghouse)	Wyoming	1978	1979	standby
Zamzow (IEC)	Texas	1978	1986	restoration
Bison Basin Pilot (OPI)	Wyoming	1979	1982	closed

©NUEXCO 1987

TABLE 5 (continued)

MAJOR PILOT AND COMMERCIAL SOLUTION MINING PROJECTS IN THE USA

Project/Operator	State	Originally Started	Shut Down	Status
Crown Point Pilot (Mobil)	New Mexico	1979	1980	closed
El Mesquite (Mobil)	Texas	1979	—	operating/restoration
Hobson (Everest Minerals)	Texas	1979	1981	standby
Longoria (Uranium Resources Inc.)	Texas	1979	1982	restoration
Benavides (Uranium Resources Inc.)	Texas	1980	1984	restoration
Collins Draw Pilot (Cleveland Cliffs)	Wyoming	1980	1982	closed
Leuenberger Pilot (Teton)	Wyoming	1980	1981	closed
Nell (Mobil)	Texas	1980	1981	closed
Bill Smith (Sequoyah)	Wyoming	1981	—	restoration
Las Palmas (Everest Minerals)	Texas	1981	1984	standby
McBryde (Caithness)	Texas	1981	1984	standby/restoration
West Cole (Tenneco)	Texas	1981	1984	standby
N. Platte Pilot (Uranium Resources Inc.)	Wyoming	1982	1982	closed
Trevino (Conoco)	Texas	1982	1984	restoration
Mt. Lucas (Everest)	Texas	1983	—	operating
Highland (Everest/Wold)	Wyoming	1984	—	pilot
Crow Butte (Ferret Exploration)	Nebraska	1986	—	pilot
Christensen Ranch (Malapai Resources)	Wyoming	1986	—	pilot
Tex-1 (Everest)	Texas	1986	—	pilot
Kingsville Dome (URI)	Texas	—	—	permitted

©NUEXCO 1987

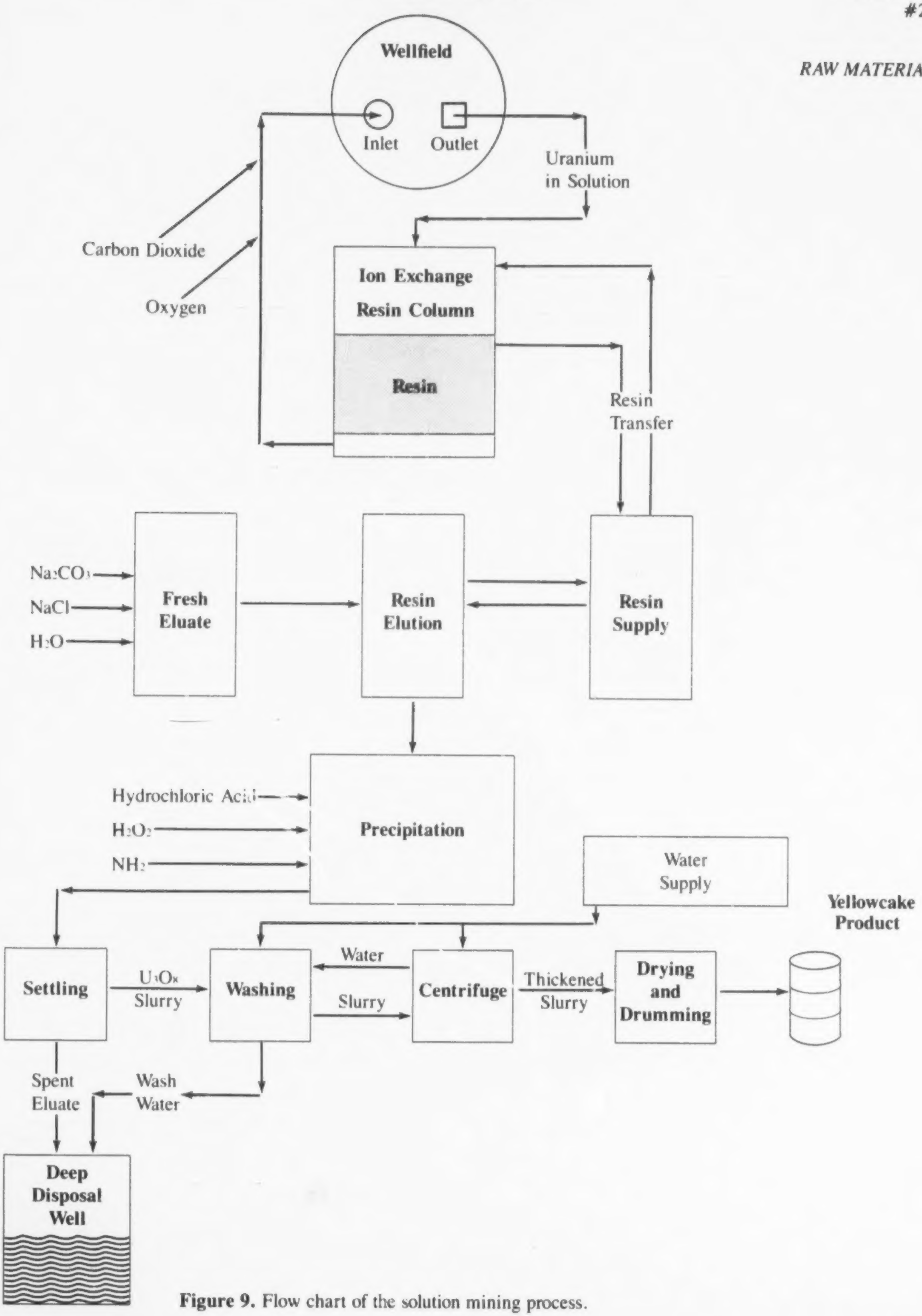
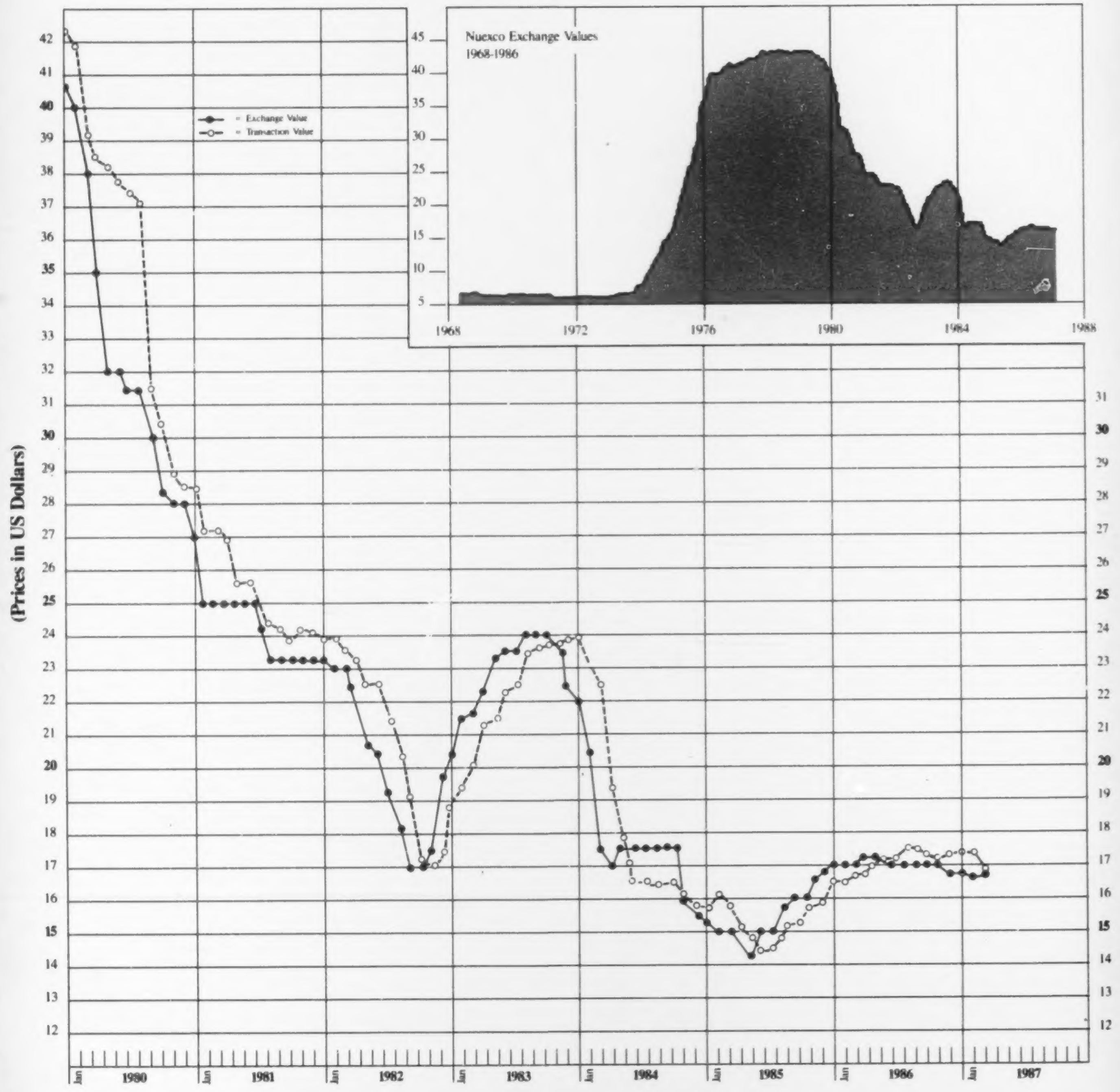

Wellfield
Inlet
Outlet
Uranium in Solution
Carbon Dioxide
Oxygen
Ion Exchange Resin Column
Resin
Resin Transfer
Na_2CO_3
NaCl
H_2O
Fresh Eluate
Resin Elution
Resin Supply
Hydrochloric Acid
H_2O_2
NH_2
Precipitation
Water Supply
Yellowcake Product
Settling
U_3O_8 Slurry
Washing
Water
Slurry
Centrifuge
Thickened Slurry
Drying and Drumming
Spent Eluate
Wash Water
Deep Disposal Well

Figure 9. Flow chart of the solution mining process.

©NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	**16.75**										

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	**16.90**										

HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	**1.80**										

HISTORICAL UF_6 VALUES

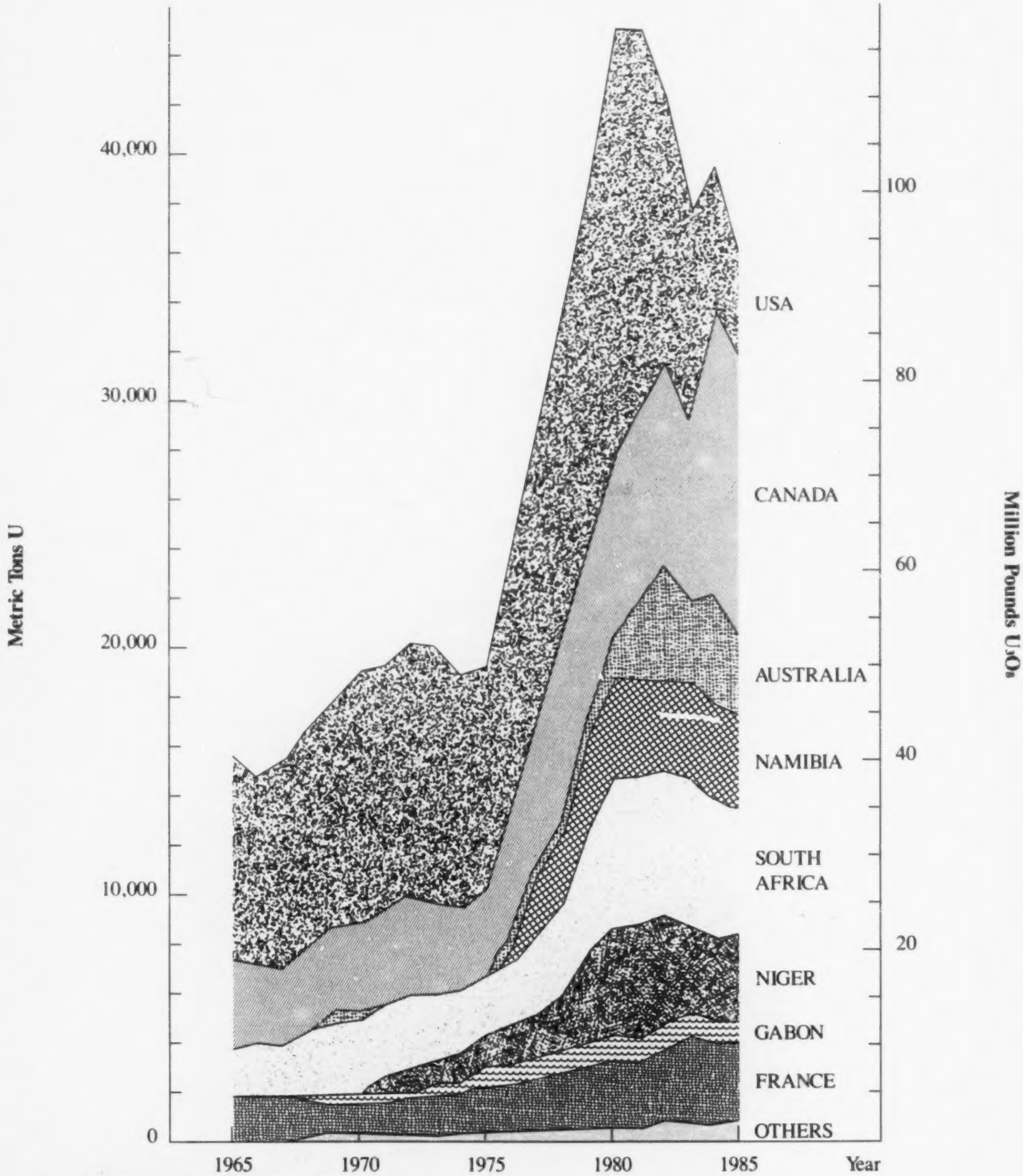
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	**48.00**										

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity,* DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity,* DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity,* DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983,* DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry,* GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

NUEXCO

GOVERNMENT STATISTICS

AUSTRALIA

	Price Index of Materials Used in Manufacturing Industry — All Groups[1] **(1984 = 100)**	**Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates**[2] **(1976 = 100)**
1975 Avg.	150.4	132.6
1976 Avg.	168.4	160.9
1977 Avg.	192.0	179.0
1978 Avg.[3] [4]	198.5	190.0
1979 Avg.	248.8	127.9
1980 Avg.	321.8	140.8
1981 Avg.	355.3	154.1
1982 Avg.[5]	368.6	174.9
1983 Avg.	401.6	181.8
FY84 Avg.[6]	95.3	—
FY85 Avg.[6]	100.0	—
Jan 1985	97.0	197.8
Feb 1985	98.6	197.8
Mar 1985	102.1	197.8
Apr 1985	104.4	202.8
May 1985	107.6	202.4
Jun 1985	108.7	202.4
Jul 1985	111.1	202.4
Aug 1985	110.5	202.4
Sep 1985	108.7	202.5
Oct 1985	108.4	202.4
Nov 1985	109.4	209.9
Dec 1985	110.0	210.0
Jan 1986	109.6	210.0
Feb 1986	108.7	210.0
Mar 1986	99.5	210.5
Apr 1986	94.3	210.5
May 1986	93.5	210.5
Jun 1986	95.7	210.5
Jul 1986	98.1	215.3R
Aug 1986	98.2	215.3R
Sep 1986	105.6	215.3
Oct 1986	106.2R	215.4
Nov 1986	105.2	215.6
Dec 1986	—	215.6

P = Preliminary   R = Revised since last month

[1] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[2] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[3] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[4] Annual averages prior to 1979 reflect index base no longer in use.

[5] Monthly data for 1979-82 appear on page 35 of Report 184.

[6] Annual averages are for financial year ending June 30.

©NUEXCO 1987

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4R	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9R	19.97	16.81R	16.11R	13.30R	11.59R	12.94R
Nov 1986	119.8	20.11P	17.04P	16.24P	13.47P	11.58P	12.93P
Dec 1986	119.8P	—	—	—	—	—	—

P = Preliminary   R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

©NUEXCO 1987

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929R	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772R	511,363R
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	755,480	531,045
Dec	1986	85.38	189.9	244.9	232.1	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

©NUEXCO 1987

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7R	297.5R	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.3	298.3	330.5	—	12.51R	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57R	13.27R	12.15R	9.75R
Dec 1986	309.3	298.1	331.1	115.3	12.61P	13.17P	12.19P	9.84P
Jan 1987	313.6	300.9	—	—	12.65P	—	12.16P	9.81P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan

Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823

SOUTH AFRICA **Chris I. Von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR

- B6800-1 A
4/15/87

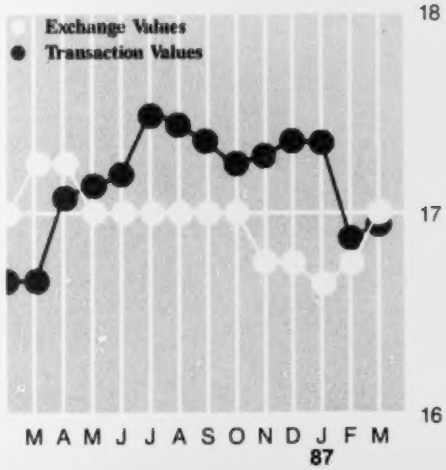
NUEXCO

Monthly Report

April 1987 Number 224

Uranium Import Licensing in the USA

Australian Politics and Uranium



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

DIRECTOR OF OPERATIONS — Transaction Services	James E. Lewis
DIRECTOR OF OPERATIONS — Information Services	J. Fred Lawrence
Manager of Fuel Transactions	Earl E. Hoellen, Jr.

Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols
Manager of Information and Consulting	R. Gene Clark

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 224
(All data as of March 31, 1987)

Exchange Value $17.00, up $0.25	The **Exchange Value** is **$17.00** per pound U_3O_8, up $0.25 since last month.
UF_6 Value $48.00, unchanged	The **UF_6 Value** is **$48.00** per kilogram U as UF_6, unchanged since last month.
Transactions	**Ten** recent natural uranium sales are reported, involving **2.2 million** pounds equivalent U_3O_8 in the near term. Nine of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. Three transactions are reported involving natural UF_6.
Supply-Demand Ratio increased to 1.9:1	Active spot and near-term **uranium supply** amounts to **3.5 million** pounds U_3O_8 equivalent, up 50 thousand pounds since last month. Active spot and near-term **uranium demand** totals **1.8 million** pounds, down 510 thousand from last month. The spot and near-term **supply-demand ratio** increased to **1.9:1.**
Transaction Value $16.95, up $0.05	The **Transaction Value** is **$16.95** per pound U_3O_8, **up $0.05** since last month. The calculation includes 20 transactions involving a total of 3.8 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.
Loan Rate unchanged at 3%	The **Loan Rate** is **3 percent** per annum, unchanged.
Conversion Value $1.80, unchanged	The **Conversion Value** is **$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 80 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.
SWU Value for delivery within one year: $77, down $3.00	The **SWU Value** at .3 tails and for delivery within one year is **$77** per SWU, down $3.00 since last month. Five secondary market SWU transactions are reported.

* * *

Analysis and Commentary	The history of import and export licensing of uranium in the USA has its roots in the 1974 Energy Reorganization Act, which created the Nuclear Regulatory Commission (NRC), and in the later formation of the Department of Energy in 1977. Export licensing, in particular, was affected by the Nuclear Non-Proliferation Act of 1978. This article examines the history of import and export licensing of nuclear materials, and discusses recent events affecting licenses.
Essay	Australia's political shifts have, over the years, greatly affected its position in the international uranium market. In addition, the Australian floor-price policy for uranium produced in that country has limited sales by Australian producers. This essay looks at Australian politics and policies as they affect its position as a major supplier of uranium.

This Executive Summary may be reproduced for internal distribution.

©NUEXCO 1987

NUEXCO

NUEXCO REPORT 224 FIGURES OF THE MONTH (March 31, 1987)	This Month (Report 224)	Last Month (Report 223)	12 Months Ago (Report 212)
Exchange Value[1]	17.00	16.75	17.25
Transaction Value[1]	16.95	16.90	16.70
UF_6 Value[2]	48.00	48.00	48.00
Loan Rate[3]	3%	3%	5%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	3.5	3.4	2.5
Near-Term Uranium Demand[6]	1.8	2.3	1.0
Near-Term Supply-Demand Ratio	1.9	1.5	2.7
Recent Uranium Sales:			
Number of Transactions[7]	10	9	5
Quantity of Material[8]	2.2	2.1	0.5
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	77	80	80
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	455	459	466
3.0 w/o U_{235}	582	586	596
3.5 w/o U_{235}	711	719	729
4.0 w/o U_{235}	842	852	864

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (223)

Section	Topic	Page
Analysis and Commentary	Uranium Consumption Forecast, 1987-2000	12
United States	Recent Legislative Developments	24
	Nuclear Waste Policy Act Update	25
Raw Materials	Solution Mining of Uranium, Part 2	27
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in February 1987	1
	Enriched Uranium and SWUs Pricing in February 1987	2

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

April 1987 No. 224

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

ANALYSIS AND COMMENTARY

Uranium Import and Export Licensing in the USA 12

ESSAY

Australian Politics and Australian Uranium:
A Commercial Anachronism 15

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 17
Historical Exchange Values and Transaction Values 18
Historical Conversion Values and UF_6 Values 19
Graph of World Uranium Production 20
US Uranium Marketing Activities Statistics 21
Volume and Price of Uranium Deliveries to the European Community 22

GOVERNMENT STATISTICS

Australia 23
Canada 24
South Africa 25
United States 26

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

©NUEXCO 1987

To Our Readers

We are extremely pleased to announce that Dr. Gene Clark has joined Nuexco at our Denver headquarters. Gene holds a Ph.D. in Nuclear Physics from Iowa State University (Ames). From 1969 to 1974 he did doctoral research at Argonne National Laboratory near Chicago and was a Research Fellow at the University of Maryland (College Park). Gene has been involved in nuclear fuel since 1974, when he joined the Federal Energy Administration's Office of Energy Information and Analysis. In 1977, when the FEA was merged into the new US Department of Energy, he became head of the Energy Information Administration's (EIA) Nuclear Energy Analysis Division. In 1981, he became Director of the Nuclear and Alternate Fuels Division of the EIA. In February 1987, he received the DOE's Exceptional Service Award for his contributions to Congress and the Executive Branch. Dr. Clark will be assuming management responsibility for Nuexco's Information Services area.

© NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of March 31, 1987)

The **Exchange Value** is **$17.00** per pound U_3O_8, up $0.25 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,495,000** pounds U_3O_8 equivalent, up 50 thousand pounds since last month. The corresponding figure for **active demand** is **1,800,000** pounds, down 510,000 pounds. The spot and near-term **supply-demand ratio** increased to **1:9 to:1.**

The *Current Market Data* section of this Report lists nine natural uranium sales, totaling 2.2 million pounds U_3O_8 equivalent in the near term. Two of the transactions involved UF_6, and one transaction involved low-enriched UF_6. Nine of the transactions met the conditions for inclusion in the Transaction Value. US-origin uranium is commanding a premium (relative to the Exchange Value) of $1.50 per pound U_3O_8 (up $0.50) in the form of concentrates, and $3.50 per kilogram U (up $1.00) in the form of UF_6.

The **Transaction Value** is **$16.95** per pound U_3O_8, up $0.05 since last month. The calculation extends over a 3-month period and includes 20 transactions involving 3.8 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$ 48.00** per kilogram U in UF_6, unchanged since last month. There remains a substantial spread between prices that discretionary UF_6 buyers are willing to pay and those that sellers will accept.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 80 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **3 percent** per annum, unchanged. One loan transaction is reported.

* * *

The Exchange Value rose $0.25 this month to $17.00 as the market exhibited a general firming. Ten sales of natural uranium involved more than two million pounds equivalent U_3O_8. Several large transactions have removed a substantial quantity of demand from the market, and although some sales reported this month involved US utilities, only one lot of material was US-origin. One US utility purchased a large quantity of low-enriched UF_6, and several European utilities purchased smaller quantities of material. Discretionary buyers indicated a greater willingness to pay somewhat higher prices during March, in part because the amount of material offered at exceptionally attractive pricing terms has greatly diminished.

The decision by several US utilities to enter the market *before* the upcoming ruling by the US Tenth Circuit Court of Appeals in the US Producers vs. DOE lawsuit, but *after* substantial earlier purchases by discretionary buyers, has increased sellers' confidence and offering prices. As of the end of the month, several US utilities were evaluating responses to their recent requests for proposals. One of these involves one million pounds for 1987 delivery, and cumulatively they represent over 13 million pounds of demand between now and the end of 1991.

Other US utilities are planning to enter the market soon, seeking both spot and intermediate to long-term supplies. If other potential buyers believe that upward price movements are likely to continue, they too may enter the market to take advantage of what they perceive is still relatively low-cost material. Such an increase in firm demand could cause additional upward pressure on prices for uranium of unrestricted origin, and for US-origin.

The premium (relative to the Exchange Value) for US-origin U_3O_8 rose $0.50 to $1.50. The increase is primarily due to two factors, whose continuation could lead to persistent upward pressure on the premium for US-origin U_3O_8.

1. Swaps have become increasingly difficult to complete. Swaps between uranium of different chemical forms and isotopic contents are now difficult or impossible to conclude; swaps between material of the same form at different locations within the USA, and swaps between material of different forms at a single location remain possible, but may face considerable difficulty gaining approval by US government agencies.

2. Some utilities interested in obtaining US-origin material through swap transactions also have become concerned that possible future judicial or legislative actions could threaten the validity of swap agreements that apparently are legitimate under current rules. As a result, some utilities have begun to insist on guarantees specifying the mine of origin, or that uranium to be bought has never been swapped, or has never carried a non-US origin label.A continuation of these trends could lead to increased upward pressure on the premium for US-origin U_3O_8.

The UF_6 Value remained unchanged this month, at $48.00 per kgU as UF_6. US-origin UF_6 is commanding a premium (relative to the UF_6 Value) of $3.50 per kgU, an increase of $1.00 since last month. Three of this month's transactions involved UF_6, totaling slightly less than one million pounds U_3O_8 equivalent. These sales effectively removed a substantial amount of UF_6 demand from the market. Canadian sellers continue to be less aggressive, offering their stocks at or above the UF_6 Value level.

©NUEXCO 1987

PRICING

* * *

The Loan Value remained unchanged this month, at three percent. One loan transaction is reported, involving less than one million pounds U_3O_8 equivalent. The emergence of firm loan demand from borrowers able to meet the stringent security requirements imposed by most lenders would likely stimulate the availability of ample supply at reasonable rates.

* * *

The Conversion Value is unchanged since last month at $1.80. One secondary market conversion transaction is reported. The market for secondary conversion services remains thin, although demand has increased slightly. Several potential suppliers of secondary market conversion services have turned down opportunities to sell at the $1.80 level, and appear to be staying out of the market until prices rise above $2.00 per pound U in UF_6. In addition, some potential sellers have negotiated attractive terms with their primary suppliers, making secondary market sales unnecessary.

ENRICHED URANIUM AND SWUS

The SWU Value declined $3.00 since last month, to $77.00 per SWU. Five SWU transactions are reported in the *Current Market Data* section of the Report, totaling over 500 thousand SWU. One US utility liquidated a large quantity of SWU this month and two non-US utilities purchased intermediate quantities. One buyer's decision to purchase a large quantity of SWU caused increased competition among SWU sellers, resulting in a decline in SWU offering prices. As the major SWU demand has been taken off the market, at least for the near-term, sellers who were unsuccessful could put additional downward pressure on secondary SWU market prices.

©NUEXCO 1987

March 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$17.00**/lb. U_3O_8	3,495	1,800
UF_6 VALUE	**$48.00**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	80	1,000
SWU VALUE 0.3 tails assay; delivery within one year	**$77**/SWU		
LOAN RATE	**3%**/annum	1,000	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**16.95**	3.8	20	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Mar 31, 1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**	**This Month (Mar 31, 1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**
Australia (dollar)	24.16	24.83	24.20	62.82	65.54	62.92
Belgium (comm. franc)	633.86	632.08	823.00	1,648	1,643	2,140
Canada (dollar)	22.22	22.32	24.09	57.77	58.01	62.53
EEC (ecu)	14.80	14.79	18.41	38.47	38.46	47.35
Finland (markka)	75.35	75.86	89.33	195.91	197.22	232.24
France (franc)	101.86	101.70	123.66	264.81	264.40	321.48
FRG (mark)	30.54	30.55	40.19	79.39	79.43	104.49
Italy (lira)	21,862	21,691	26,038	56,837	56,392	67,692
Japan (yen)	2,484	2,564	3,098	6,457	6,666	8,052
Netherlands (guilder)	34.57	34.52	45.53	89.87	89.75	118.36
South Africa (rand)	34.07	34.54	35.75	88.57	89.79	92.95
Spain (peseta)	2,157	2,145	2,510	5,607	5,576	6,525
Sweden (krona)	107.32	107.93	126.65	279.02	280.58	329.27
Switzerland (franc)	25.48	25.73	33.50	66.24	66.89	87.25
UK (pound)	10.58	10.87	11.68	27.49	28.25	30.36
US (dollar)	17.00	16.75	17.25	44.20	43.55	44.35

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Mar 31, 1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**	**This Month (Mar 31,1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**
Australia (dollar)	24.09	25.05	23.43	62.64	65.12	60.91
Belgium (comm. franc)	631.99	637.74	796.76	1,643	1,658	2,071
Canada (dollar)	22.15	22.52	23.32	57.60	58.53	60.63
EEC (ecu)	14.76	14.93	17.83	38.36	38.80	46.35
Finland (markka)	75.13	76.54	86.48	195.33	198.99	224.84
France (franc)	101.56	102.61	119.71	264.03	266.77	311.23
FRG (mark)	30.45	30.83	38.91	79.16	80.15	101.16
Italy (lira)	21,798	21,886	25,208	56,670	56,897	65,543
Japan (yen)	2,476	2,587	2,999	6,438	6,725	7,796
Netherlands (guilder)	34.47	34.83	44.08	89.60	90.55	114.59
South Africa (rand)	33.97	34.85	34.61	88.31	90.59	89.98
Spain (peseta)	2,150	2,164	2,430	5,590	5,626	6,317
Sweden (krona)	107.01	108.89	122.61	278.20	283.09	318.77
Switzerland (franc)	25.40	25.96	32.49	66.05	67.49	84.47
UK (pound)	10.54	10.96	11.31	27.41	28.50	29.39
US (dollar)	16.95	16.90	16.70	44.07	43.94	43.42

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Mar. 31, 1987.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF₆			per kg. U as UF₆		
Country (currency)	**This Month (Mar 31, 1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**	**This Month (Mar 31, 1987)**	**Last Month (Feb 28, 1987)**	**12 Months Ago (Mar 31, 1986)**
Australia (dollar)	2.56	2.67	2.53	5.64	5.88	5.57
Belgium (comm. franc)	67.11	67.92	85.88	147.96	149.75	189.33
Canada (dollar)	2.35	2.40	2.51	5.19	5.29	5.54
EEC (ecu)	1.57	1.59	1.92	3.45	3.50	4.24
Finland (markka)	7.98	8.15	9.32	17.59	17.97	20.55
France (franc)	10.78	10.93	12.90	23.78	24.09	28.45
FRG (mark)	3.23	3.28	4.19	7.13	7.24	9.25
Italy (lira)	2,315	2,331	2,717	5,103	5,139	5,990
Japan (yen)	262.97	275.52	323.22	579.74	607.43	712.57
Netherlands (guilder)	3.66	3.71	4.75	8.07	8.18	10.47
South Africa (rand)	3.61	3.71	3.73	7.95	8.18	8.22
Spain (peseta)	228.34	230.50	261.89	503.40	508.17	577.38
Sweden (krona)	11.36	11.60	13.22	25.05	25.57	29.14
Switzerland (franc)	2.70	2.76	3.50	5.95	6.10	7.72
UK (pound)	1.12	1.17	1.22	2.47	2.57	2.69
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF₆ VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Mar 31, 1987)**	**UF₆ Value per kg.U in UF₆ This Month (Mar 31, 1987)**	**UF₆ Value per kg.U in UF₆ Last Month (Feb 28, 1987)**
Australia (dollar)	109.45	68.23	71.14
Belgium (comm. franc)	2,871	1,790	1,811
Canada (dollar)	100.64	62.73	63.94
EEC (ecu)	67.03	41.78	42.39
Finland (markka)	341.31	212.76	217.39
France (franc)	461.35	287.59	291.43
FRG (mark)	138.32	86.22	87.55
Italy (lira)	99,023	61,728	62,160
Japan (yen)	11,249	7,012	7,347
Netherlands (guilder)	156.57	97.60	98.92
South Africa (rand)	154.31	96.19	98.96
Spain (peseta)	9,768	6,089	6,147
Sweden (krona)	486.11	303.03	309.27
Switzerland (franc)	115.41	71.94	73.73
UK (pound)	47.90	29.86	31.13
US (dollar)	77.00	48.00	48.00

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on Mar. 31, 1987.

©NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
3993	1987	50-100	99	Producer	Utility	
3995	1987	301-600	99	Trader	Utility	
3996	1987	101-300	101	Producer	Trader	
3997	1987	101-300	99	Utility	Trader	
3998A	1987	601-1,000	R[5]	R[5]	Utility	Enriched UF_6
3999	1987	50-100	99	Trader	Utility	UF_6
4007	1988	50-100	101	Trader	Trader	UF_6
4008	1988	50-100	111	Trader	Utility	US-origin
4010	1987	101-300	103	Producer	Utility	
4011	1987	101-300	100	Trader	Utility	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
3987	1987	101-300	94	Trader	Utility	

Loan Transactions

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Loan Rate	Lender	Borrower	Remarks
4012	1987	601-1,000	R[5]	Utility	Trader	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
3986	1987	less than 50	107	R[5]	Fabricator	R[5]	
3988	1987	less than 50	101	Trader	Utility	Eurodif	
3998B	1987	101-300	R[5]	R[5]	Utility	R[5]	
4000	1987	50-100	99	Trader	Utility	DOE	
4001	1987	101-300	94	Utility	R[5]	DOE	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(March 31, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2335	420	—	
2740	250	—	
2893A	720	—	UF_6
2933	300	300 per year	1988-90
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121	500	—	
3129*	500	1,000	
3166*	50	—	
3221*	200	—	
2263	—	400 per year	1989 on
2781	—	750 per year	1988-95
2996	—	500 per year	1988-90
3171	—	200 per year	1988-92
TOTAL:	3,495		
INACTIVE			
2297	100	100 per year	1988-89
2389	300	—	
2764*	520	—	UF_6
2967*	1,000	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
TOTAL:	1,970		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: None.

©NUEXCO 1987

URANIUM DEMAND
(March 31, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Inquiries to Purchase: ACTIVE			
2890	175	—	
2897*	300	—	
2984*	170	—	U_3O_8 and UF_6
2991	105	—	UF_6
3120	1,000	1,000 per year	1988-91
3192	50	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962*	—	500 per year	1988 on
2985	—	675 per year	1992 on
3137*	—	4,800 per year	1993-97
3147	—	200	1988-92
3193	—	700 per year	1989,91,94,96
3209*	—	150 per year	1989-1991
TOTAL:	1,800		
INACTIVE			
2760	750	750 per year	1988-90
2798*	150	—	
2911	65	—	UF_6
TOTAL:	965		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2878A, 2956, 3009.

©NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(March 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6)		
	Within 3 Years	**Beyond 3 Years**	**Remarks**
Available for Sale: ACTIVE			
3222*	80	—	
TOTAL:	80		
Available for Sale: INACTIVE			
2859*	750	750	
2988*	165	—	
3165*	330	—	
TOTAL:	1,245		
Inquiries to Purchase: ACTIVE			
3120	1,000	700	1988-89
TOTAL:	1,000		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

LOAN SUPPLY AND DEMAND
(March 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8)		Remarks
	Within 1 Year	Beyond 1 Year	
Available for Loan:			
ACTIVE			
2909*	1,000	—	
TOTAL:	1,000		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912*	1,000	—	
2920	2,000	—	
TOTAL:	5,500		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

No inquiries to borrow are reported this month.

SWU SUPPLY AND DEMAND
(March 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs)		Remarks
	Spot or Near-term[2]	Intermediate or Long-term	
Available for Sale:			
ACTIVE			
2571	55	—	1987
2969	200	—	1987
3156	70	—	1987
3162	50	—	1987
TOTAL:	375		
Inquiries to Purchase:			
ACTIVE			
2999	150	—	1987
3159*	30	—	1987
TOTAL:	180		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2878, 3009, 3043, 3213.

ANALYSIS AND COMMENTARY

URANIUM EXPORT AND IMPORT LICENSING IN THE USA

Introduction

Much of the recent legislative history of licensing of nuclear materials in the USA can be traced to the 1974 Energy Reorganization Act, which went into effect on October 11, 1974. This Act abolished the Atomic Energy Commission (AEC) and created two new government agencies, the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Agency.

Prior to 1974, export licenses and approvals for retransfer of radioactive materials were issued by the AEC. The AEC verified that the quantity, enrichment and end use of the material complied with the negotiated and approved guidelines of bilateral agreements for nuclear cooperation. After this check for compliance, an export license was issued, or a government-to-government approval was signed. This exercise took from a few hours to a few days. The AEC's first export license was issued on February 1, 1968 to General Electric, to ship .002 kgs of U_{235} to Magnetic AB of Bromma, Sweden.

Energy Reorganization Act

By 1975, the recently-formed NRC found that its issuing, holding or denying export licenses for nuclear materials and components increasingly placed it in the awkward position of having to make *de facto* foreign policy decisions as well as become involved in issues of the common defense and security of the nation. The difficulty of the situation caused the NRC Commissioners to stop issuing licenses for approximately six months while this situation was clarified. On February 2, 1976, President Gerald Ford issued an Executive Order which designated the State Department as the agency having the greatest discretionary authority. "The Secretary of Defense, the Secretary of Commerce, the Administrator of the Energy Research and Development Agency, the director of the Arms Control and Disarmament Agency, and the head of any other department or agency which may have an interest therein..." were instructed to confer with the State Department, offering their views on whether and under what conditions licenses should be issued. Although each agency newly involved in the licensing process had to create and educate their staffs in the complexities of the worldwide nuclear industry, the 1976 Executive Order helped to get the stalled export licensing process moving again, although at a slow pace.

In August 1977, Congress established the Department of Energy (DOE). DOE then took over all aspects of national energy policy. The Office of Energy Research within DOE assumed the functions of the Energy Research and Development Agency.

Nuclear Non-Proliferation Act of 1978

In 1978, the "Nuclear Non-Proliferation Act of 1978" (NNPA) was signed into law. An evaluation of the international nuclear fuel cycle, which had been started by President Carter in 1977, was well underway when it was preempted by the NNPA. Without waiting for the recommendations of scientists belonging to the international evaluation team, the NNPA banned reprocessing of US-supplied nuclear materials and required the renegotation of all bilateral agreements for nuclear cooperation. (Some of the existing agreements are still being renegotiated and probably never will be completed.) The NNPA established procedures and general time schedules for processing export licenses and other arrangements. These procedures were published in the Federal Register on June 9, 1978 and were revised on May 19, 1984.

Revised Federal Code

On December 31, 1984, the NRC published its completely rewritten "Title 10 Code of Federal Regulations-Energy Part 110 Rules and Regulations for Export and Import of Nuclear Facilities and Materials". Effective January 1, 1985, this revised code allowed "general" export licenses for components, small quantities of nuclear material for research, safeguarded samples, and various nuclear by-products for industrial use. A "general license" is an export or import license that does not require filing of a specific application. A general license could be issued to import by-product, source or special nuclear material, not exceeding 100 kgs of irradiated fuel, provided the consignee is authorized to possess the material. A "specific license" means an export or an import license issued to a named entity in an application filed pursuant to Part 110.

The NRC staff has the authority to issue (or deny) licenses without review by the NRC Commissioners in all cases except those involving:

1. A production or utilization facility;
2. More than one effective kilogram of high-enriched uranium, plutonium or U_{233};
3. 1,000 kilograms or more of heavy water or nuclear-grade graphite;
4. Exports related to isotope separation, chemical reprocessing, heavy water production, advanced reactors or fabrication of nuclear fuel containing plutonium, except for categories of export approved in advance by the Commission;

©NUEXCO 1987

5. Initial export to a country (since March 10, 1978) of source or special nuclear material for nuclear end use;
6. An export involving over (a) 10 grams of plutonium, U_{233} or high-enriched uranium; (b) 1 effective kilogram of low-enriched uranium; (c) 250 kgs of source material, heavy water or nuclear grade graphite; or (d) 1,000 curies of tritium, to any country listed in 110.28 or 110.29 (non-NPT or agreement countries).

Prior to the revision of the code, each component or reload of material for export went through the entire licensing examination process as required in the NNPA. The process for examination and interagency actions are as follows:

1. An applicant with a US address submits an application to the NRC on Form 7.
2. Within 15 days of receipt, the NRC forwards a copy of the application to the Department of State and the other four agencies outlined in the NNPA.
3. The executive branch agencies have 15 days to advise the Department of State if they need additional information to make their judgment.
4. If no additional information is required, the Department of State has 30 days to draft the Executive Branch draft views for comment by the other executive branch agencies involved, who then have 10 days to reply to the draft views. Altogether, the Executive Branch has 60 days to advise the NRC of its views.
5. During this 60-day period, the Department of Energy must request and receive confirmation from the recipient country that:
   a. the export is subject to the agreement for nuclear cooperation;
   b. the consignee is authorized to receive the material, and;
   c. the material will be maintained under IAEA physical security measures.
6. The NRC has an additional 60 days after receiving the executive branch views to take action on the application or inform the applicant of the reason for delay. If the Commission cannot agree on a course of action, it may pass the case to the President (who may, by Executive Order, approve the export after it has been before the NRC for more than 120 days).
7. If the President does approve the export, Congress has 60 days to vote to override the Executive Order. (The precedent for congressional review and override was the 1978 export to India of a reload for the Tarapur reactors).

Since May 1984, when the NNPA Administrative Procedures were revised, the NRC has been able to issue all licenses without Executive Branch review, except in cases involving:

1. A production or utilization facility;
2. More than one effective kilogram of high-enriched uranium, or 10 grams of plutonium or U_{233};
3. Deuterium, nuclear grade graphite or over 100 curies of tritium;
4. Source or special nuclear material to be exported under the US-IAEA Agreement for Cooperation (rather than the individual bilateral agreement);
5. An export involving assistance related to isotope separation...as constituting permitted incidental assistance;
6. The initial export of material or equipment to a foreign reactor;
7. An export to a country without an agreement with the USA, or;
8. An export subject to special limitations.

Thus, licensing by the NRC can now be handled largely at the staff level. Also, any transfer to a third country licensed at the time of the original export can proceed without US prior approval for that transfer. For example: UF_6 licensed for export to Euratom for enrichment may go on to Japan, Sweden or Switzerland for fabrication or final reactor use if that information was supplied at the time of the export, and the reshipment takes place within the validity period of the export license.

As a result of the Freedom of Information Act of 1976 and the Government in the Sunshine Act of 1978, all license applications and unclassified correspondence relating to them are available in the NRC public document room. NRC regulations describe to the public how to comment, request a hearing, or petition for leave to intervene.

Import Licensing

The focus of the NNPA was to prevent exports of nuclear material or components that might be used in ways not approved by the US government; thus, during the years prior to 1986, challenges to licenses issued by the NRC involved export licenses. However, since the 1986 enactment of sanctions legislation against South Africa and Namibia, the issue of *import* licenses has become paramount.

A considerable amount of confusion has surrounded the meaning of that portion of the "Comprehensive Anti-Apartheid Act of 1986" (the Act) applicable to uranium imports from South Africa. Whether the law applied to South African UF_6, enriched UF_6, or uranium imported into the USA for processing and reexport has been a matter for interpretation by the Department of the Treasury. Until

©NUEXCO 1987

December 31, 1986, the NRC had issued general licenses for import of uranium of any origin (excluding quantities of irradiated fuel exceeding 100 kgs) into the USA. Effective January 1, 1987, the NRC enacted a requirement for specific licenses for the import of uranium of South African or Namibian origin. The apparent intent was to prevent those imports in accordance with the provisions of the Act.

On March 10, 1987, the US Treasury Department published a final rule which provides essentially that UF_6 is not covered by the sanctions against importation. Effective December 31, 1986, Section 545.425 is added to provide:

> "Substantial transformation of uranium ore and oxide.
>
> Articles such as uranium hexafluoride, which are produced from uranium ore or uranium oxide and which the U.S. Customs Service determines to have been substantially transformed outside the United States, are not subject to the import prohibition of Section 545.211."

In addition, the Treasury Department published an interim rule which provides that uranium in *any* form may be imported for processing and reexport until July 1, 1987.

> "Interim Regulation Section 545.427 is added to read: (a) The prohibition in Section 545.211 does not apply to importation in bond of uranium ore or uranium oxide produced or manufactured in South Africa, when such importation is made solely for processing in the United States and exportation of the products of that processing, provided that the following requirements are met.
>
> (1) the importation of the uranium ore or oxide has been authorized by a license issued by the U.S. Nuclear Regulatory Commission (NRC), satisfactory evidence of which is presented to the U.S. Customs Service prior to or at the time of importation;
>
> (2) the importation is properly classified under Item No. 864.05 of the Tariff Schedules of the U.S. as an importation in bond for processing and reexport; and
>
> (3) if the uranium ore or oxide was produced, marketed or otherwise exported by a parastatal organization of South Africa, the importation is pursuant to a contract entered into prior to August 15, 1986, and occurs no later than April 1, 1987."

["Parastatal organization" means a corporation or partnership owned or controlled or subsidized by the Government of South Africa. There are no parastatal organizations involved in producing South African uranium.]

The Treasury Department is receiving written congressional and public comments on the interim rule prior to May 11, 1987, and will likely issue a final rule on or before July 1, 1987. It is possible that Congress could render the license issue moot by amending the Anti-Apartheid Act to prohibit *any* imports of South African or Namibian uranium, in any form. Congress could also do the job it should have done originally, and amend the law to clarify its intent with respect to UF_6 and transient imports (temporary importation and reexport for eventual use by non-US organizations).

Since before 1985, eleven specific licenses have been in effect for the importation of unspecified origin, South African or Namibian uranium; these licenses, held by nine companies, are still considered valid. However, the Lawyers Committee for Civil Rights under Law, several Congressmen, and five other organizations have asked the NRC to revoke these licenses. The same groups also have petitioned for leave to intervene in eight applications for specific licenses for import and export of South African-origin uranium. Such intervention, if successful, would block the issuance of those eight licenses and would effectively preclude new applications for similar licenses.

The petitioners had 30 days after the license applications to file their petition, after which involved parties, including the NRC staff and the applicant(s), had 30 days to respond to petitions before the Commissioners. The NRC then had 10 days to reply to the responses supplied by the involved parties. The Commission's reply to the applicants and the NRC staff is expected in April 1987, but a delay would not be surprising. The NRC has neither revoked nor amended the *existing* import licenses valid for South African-origin material (regardless of form).

The approval or denial of import licenses for shipments of South African or Namibian-origin uranium has caused concern both about issues of nuclear non-proliferation and of compliance with the Anti-Apartheid Act. In general, most of the controversy has focused on interpretation of the sanctions against South Africa. However, the petitioners seeking to intervene in the license applications do so, in part, using the reasoning that allowing those imports would not be in the best interest of the common defense and security of the USA, because the South African uranium industry, and the profits to be made through the sale of its uranium, are integral to that country's nuclear energy program and nuclear weapons development effort.

Although the issuance or denial of import and export licenses has always had a potential role in US government nuclear policy implementation, that role has become much more visible since the enactment of the sanctions legislation against South Africa. A resolution of the controversy over the form in which South African uranium may be imported is sure to be reflected by approval (or maintenance of the status quo), rejection, or cancellation of certain import and export licenses.

AUSTRALIAN POLITICS AND AUSTRALIAN URANIUM: A COMMERCIAL ANACHRONISM

Many of Australia's current and prospective customers continue to view the Australian government's political involvement with uranium as unsettling. Simply put, customers do not yet believe Australia is a reliable source of supply. Given the existing portfolio of contracts, these observations may appear to contradict the reality of Australia's present market position. But that reality must be viewed in the context of both what it might have been, and what the future holds.

The actions (and inactions) of successive Australian governments with respect to uranium have fundamentally altered the development of the uranium market. As control of Australia's federal government shifted from Liberal to Labor, back to Liberal, and most recently back to Labor, so too did its uranium policies shift. Potential customers were understandably confused. These unpredictable policy shifts caused Australia to forfeit, probably forever, the opportunity to become the world's largest uranium producer.

The policy shifts and resulting delays reflected both historical and more recent concerns within Australia. These included the usual policy considerations associated with the exploitation and fair pricing of Australia's depletable resources (the "Quarry Australia" syndrome), as well as aboriginal land rights, the influence of an emerging environmental movement, and questions about nuclear weapons safeguards and proliferation. While these are matters of understandable national concern, the process of sorting them out has been time-consuming and, to non-Australians, has appeared confused and hesitant.

By the simple expedient of maintaining a reasonable, consistent and economically realistic uranium policy, Australia could have assured for itself considerably greater commercial and political influence in this arena. But the government's inaction and vacillation squandered that opportunity. Canada seized the initiative and now dominates the market. Australia will remain an important supplier, but now can aspire to being no more than a distant second, and even attainment of that position could well be delayed. Or it may come about only by default — the result of security of supply concerns associated with political developments in southern Africa — unless Australia alters the way it does business.

Despite its often-observed propensity "to shoot itself in the foot" whenever the opportunity arises, Australia does enjoy certain advantages. Foremost among these is its vast resource base which, by any measure, is the largest in the world. According to the 1986 OECD Report (the Red Book), Australia's reasonably assured resources recoverable at less than $80/kg U exceed 1.2 billion pounds U_3O_8, and represent nearly 28 percent of the WOCA total. When estimated additional resources are added, the total exceeds 2.2 billion pounds, and speculative resources could add another 10 billion pounds.

Indeed, Australia's potential to be a leading supplier nation in the world was recognized as early as 1971. Queensland Mines' high grade Nabarlek deposit had been identified, as had the much larger Jabiru and Jabiluka deposits owned by Ranger and Pancontinental. Ranger and Queensland concluded sales to Japanese utilities in 1972 and 1973. In addition, uranium from the Mary Kathleen mine in Queensland was being delivered to customers in the USA, Europe and Japan.

It is not surprising that buyers, particularly those without indigenous supply, are attracted to Australian resources and are interested in forming supply relationships with Australian suppliers, regardless of the difficulty and frustration of doing business there. With the need to supply reactors with uranium for 30 to 40 years, nuclear utilities must take a long-term view and can ill afford to ignore such a potentially huge supply source. But without security of supply, reliability, and commercial realism, even the largest sources cannot be taken seriously.

Australia also benefits from the inclination of buyers toward geographical diversification of supply sources. The most obvious reason is to enhance security of supply, by reducing the impact of any one country's failure to deliver as scheduled. (Australia's embargo on deliveries to France and Canada's year-long 1977 embargo on uranium exports are two examples.) A more fundamental reason is found in the normal desire of all buyers for flexibility, associated with operating in markets that are characterized by excess capacity. Such markets allow buyers to exercise some measure of market discipline over sellers, through producer competition stimulated by the implicit threat of shifting their business. For the same reasons, producers are encouraged to proceed with new projects before that new supply is actually required.

Thus, Australian uranium contracts are needed and used to offset Canada's dominance, and could assume even greater importance if the availability of southern African supplies becomes even more uncertain. Accordingly, Energy Resources of Australia (ERA) was launched in 1980, even as prices began collapsing, and Olympic Dam is now contracting for base load business, even with prices at historically low levels.

Since the average price now being paid for Australian uranium is the highest of any country in the world, other

ESSAY

countries might well wonder if they shouldn't also "shoot themselves in the foot" now and again. It seems clear, however, that Australia's unusually good position will change with the completion of contracting from Olympic Dam. By that time Australia will be a viable and committed producing nation. Western Mining (the primary owner of Olympic Dam) and ERA will be natural and aggressive rivals within Australia, providing intra-country discipline, and together they will provide a credible alternative to Canada. Under such circumstances it is unlikely that new buyers will feel the need to accept a government-mandated floor price policy or the current contract review and approval procedures. Having come of age as a producing country, Australia will become subject to the same market disciplines imposed on others.

Already there are signs that this process has started.

1. ERA's contracts with US utilities do not involve firm quantities on a take and pay basis; rather they have flexible tonnage based on prevailing prices.

2. The original floor price concept that *all* deliveries *must* be at prices equal to or in excess of the floor price has been replaced by the concept that the *average price*, over the life of the contract, *should* equal or exceed the floor price.

3. ERA's shareholder/buyers insisting upon a reduction in their prices, to less than US $30.00 per pound (i.e., less than the current floor price).

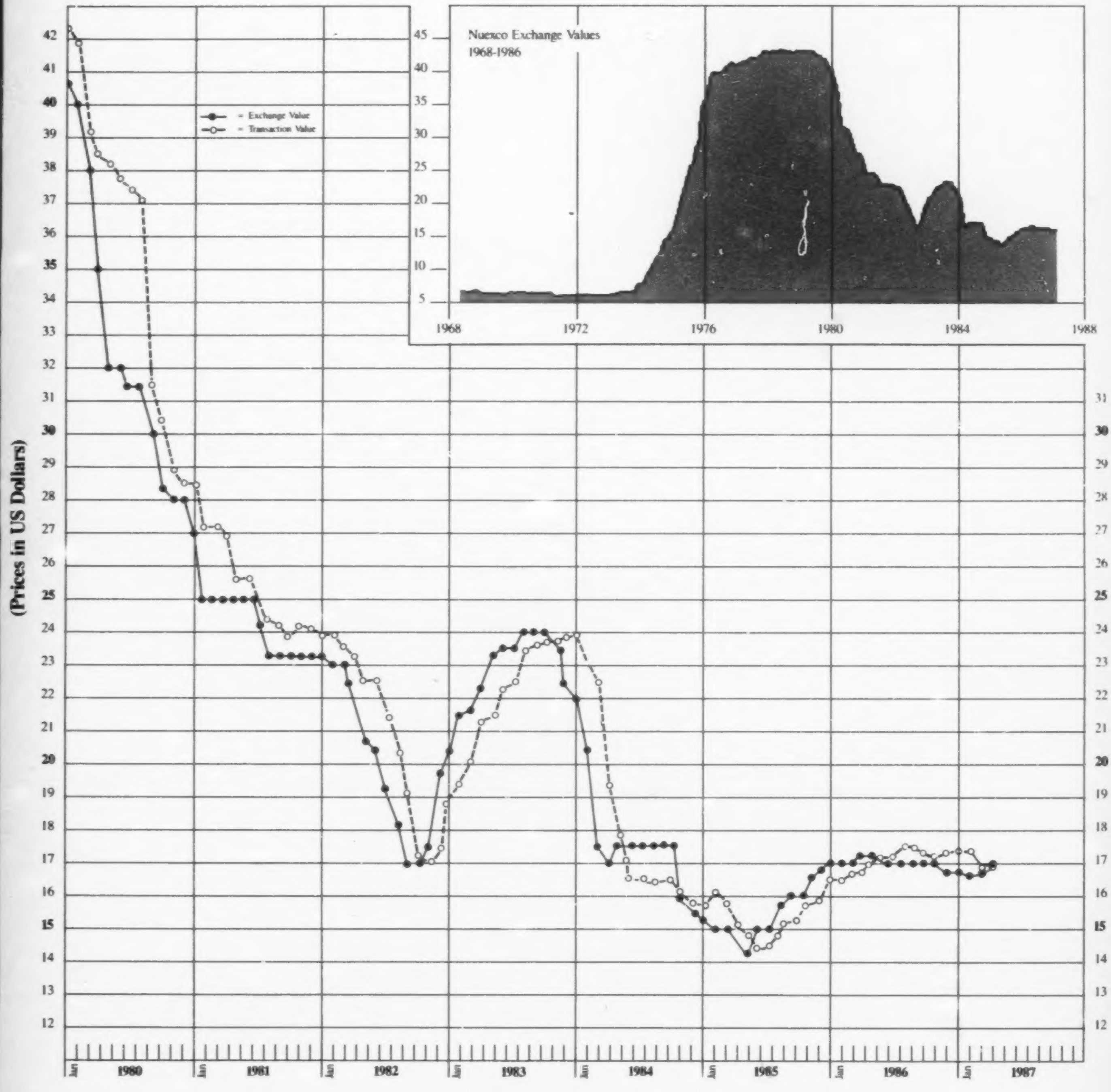
It appears that, for all practical purposes, Australia's floor-price policy is about to become, or may have already become extinct. While the Australian government will undoubtedly and understandably deny that this is the case, the reality of the situation is otherwise. If prices remain weak, the current pressure on Australia to reduce or eliminate the floor price can only intensify, and Australian resistance to accommodation would result not only in reduced purchase commitments in the future, but also provide the opportunity and incentive for other producers in other countries to seek market entry.

If prices rise, however, there would be no need for a floor price. In either event, it is clear that the floor price is no longer either acceptable or relevant. Similarly, the current review and approval process will have to give way to a more streamlined procedure that is responsive to the market's needs. The current situation effectively precludes Australian participation in the spot market. Although Australian producers now ignore that market, participation will undoubtedly become desirable at some point in the future.

Australia is in the process of moving into the ranks of the major producing nations and will have to learn to play by the same rules as the other participants in the international market. Failure to recognize its changing circumstances, and act accordingly, would once again prove very costly.

©NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

NUEXCO

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	**17.00**									

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	6.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	**16.95**									

©NUEXCO 1987

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	**1.80**									

HISTORICAL UF_6 VALUES

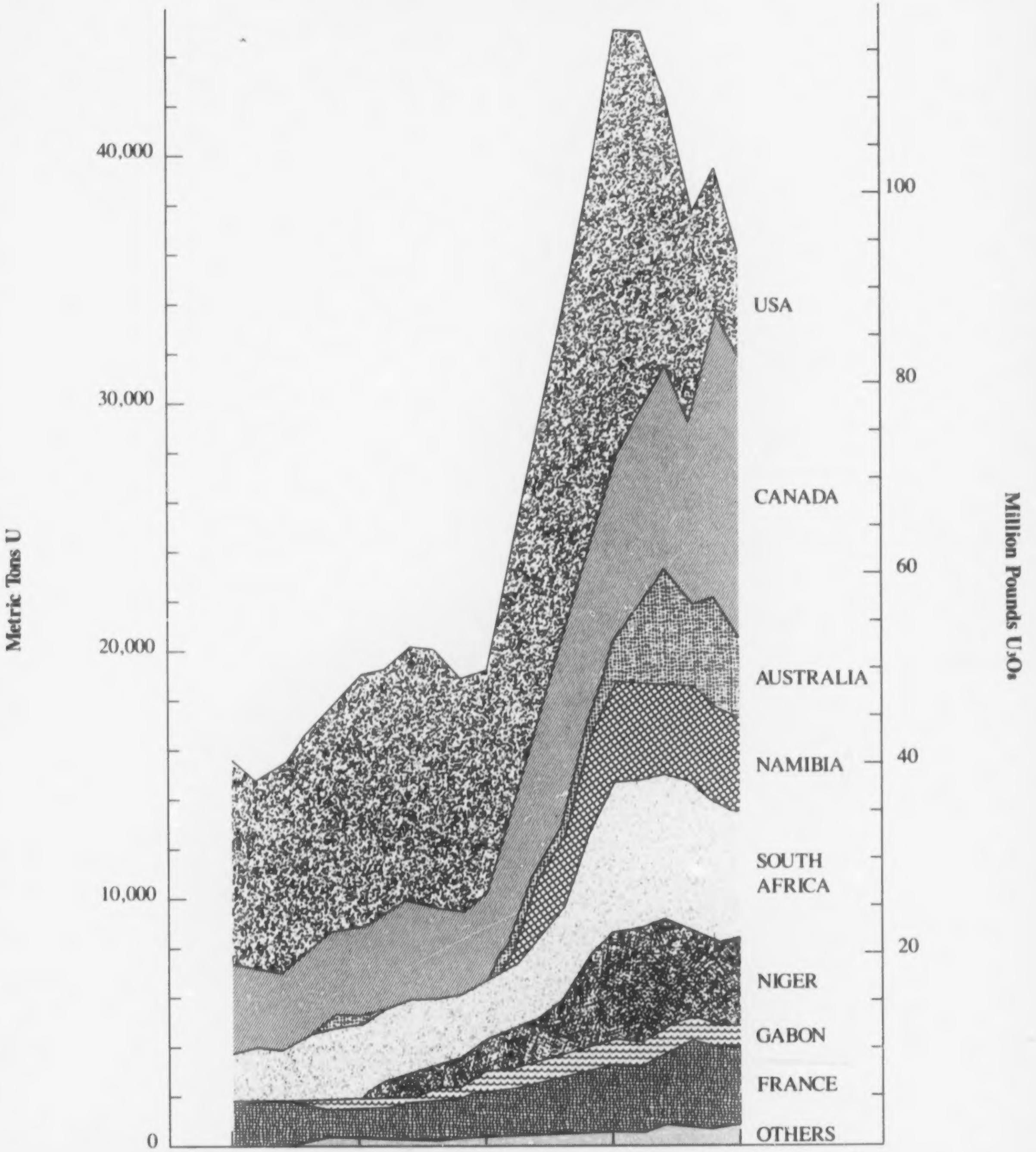
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	**48.00**									

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

AUSTRALIA

	Consumer Price Index[1]	**Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)**	**Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1975 = 100)**
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4] [5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]		100.0	—
Jan 1985		97.0	197.8
Feb 1985		98.6	197.8
Mar 1985		102.1	197.8
Apr 1985		104.4	202.8
May 1985		107.6	202.4
Jun 1985		108.7	202.4
Jul 1985		111.1	202.4
Aug 1985		110.5	202.4
Sep 1985		108.7	202.5
Oct 1985		108.4	202.4
Nov 1985		109.4	209.9
Dec 1985	142.6	110.0	210.0
Jan 1986		109.6	210.0
Feb 1986		108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986		94.3	210.5
May 1986		93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986		98.1	215.3
Aug 1986		98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986		106.2	215.4
Nov 1986		105.2	215.6
Dec 1986		105.5	215.6
Jan 1987		—	215.5

P = Preliminary R = Revised since last month

---

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5] Annual averages prior to 1979 reflect index base no longer in use.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

[7] Annual averages are for financial year ending June 30.

©NUEXCO 1987

GOVERNMENT STATISTICS

CANADA

		Wage-earner Data: Average Hourly Earnings (C$)[2]					
	Industry Selling Price Index: All Commodities[1] (1981 = 100)	**Uranium Mines (SIC 057)**	**Metal Mines (SIC 051-059)**	**Mines, Quarries and Oil Wells[3] (SIC 051-099)**	**Primary Non-ferrous Metal Industries[4] (SIC 296)**	**Primary Non-ferrous Metal Industries[4] (SIC 298)**	**Chemicals and Chemical Products[5] (SIC 372-379)**
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.2R	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9R	20.11	17.01R	16.24	13.42R	11.66R	12.93
Dec 1986	119.7R	19.67P	16.79P	16.19P	13.06P	1157P	12.99P
Jan 1987	119.9P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

©NUEXCO 1987

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
Jan	1985	—	—	177.1	166.6	711,366	376,777
Feb	1985	—	—	182.8	171.3	727,932	361,823
Mar	1985	64.48	142.4	183.6	173.0	708,809	371,380
Apr	1985	—	—	187.4	174.0	724,187	369,005
May	1985	—	—	189.5	177.7	708,085	373,478
Jun	1985	67.42	148.9	191.9	179.2	724,587	395,543
Jul	1985	—	—	193.6	180.7	738,228	419,106
Aug	1985	—	—	195.6	183.2	734,121	416,777
Sep	1985	70.47	155.3	197.8	184.8	732,836	419,883
Oct	1985	—	—	200.8	188.1	720,071	401,448
Nov	1985	—	—	203.4	196.0	750,049	432,996
Dec	1985	72.43	160.1	207.4	199.4	741,372	425,261
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325R	531,509R
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
Jan 1985	322.9	309.5	316.1	—	13.29	13.70	11.39	9.33
Feb 1985	322.5	309.2	317.4	—	13.30	13.73	11.39	9.33
Mar 1985	322.6	308.7	318.8	110.4	13.29	13.95	11.37	9.39
Apr 1985	323.8	309.3	320.1	—	13.43	13.63	11.47	9.40
May 1985	325.3	309.8	321.3	—	13.24	13.60	11.44	9.39
Jun 1985	324.8	309.2	322.3	111.3	13.23	13.68	11.51	9.46
Jul 1985	324.4	309.0	322.8	—	13.45	13.83	11.59	9.47
Aug 1985	323.7	307.3	323.5	—	13.55	13.71	11.60	9.50
Sep 1985	322.3	305.5	324.5	112.1	13.44	13.68	11.65	9.54
Oct 1985	324.2	307.9	325.5	—	13.49	13.66	11.70	9.55
Nov 1985	324.7	309.5	326.6	—	13.49	13.97	11.80	9.61
Dec 1985	325.1	310.2	327.4	113.0	13.43	13.81	11.85	9.68
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6R	298.4R	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70R	13.16R	12.20R	9.85R
Jan 1987	313.6	300.9	333.1	—	12.86R	13.13	12.18R	9.87R
Feb 1987	315.7	302.7	334.4	—	—	—	12.20P	9.87P

P = Preliminary   R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan

Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823

SOUTH AFRICA **Chris I. Von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR

BOSCO 1 A-
5/1-1.7

NUEXCO

Monthly Report

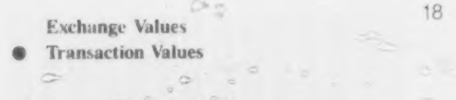
May 1987 Number 225

Five-Year Uranium Production Forecast

Japanese Utilities Plan New Nuclear Construction

First-Quarter South African Production Results

By-Product and Co-Product Uranium Resources and Production



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

DIRECTOR OF OPERATIONS — Transaction Services	James E. Lewis
DIRECTOR OF OPERATIONS — Information Services	J. Fred Lawrence

Manager of Fuel Transactions	Earl E. Hoellen, Jr.

Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols
Manager of Information and Consulting	R. Gene Clark

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 225
(All data as of April 30, 1987)

Exchange Value $17.00, unchanged

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month.

UF_6 Value $48.00, unchanged

The **UF_6 Value** is **$48.00** per kilogram U as UF_6, unchanged since last month.

Transactions

Eight recent natural uranium sales are reported, involving **3.8 million** pounds equivalent U_3O_8. Six of the sales involved spot or near-term delivery, and five met the conditions for inclusion in the Transaction Value. Two transactions are reported involving low-enriched UF_6, totaling approximately 320,000 pounds equivalent U_3O_8.

Supply-Demand Ratio increased to 7.8:1

Active spot and near-term **uranium supply** amounts to **4.5 million** pounds U_3O_8 equivalent, up **one million pounds** since last month. Active spot and near-term **uranium demand** totals **575 thousand** pounds, down **1.2 million** pounds from last month. The spot and near-term **supply-demand ratio increased** to **7.8:1.**

Transaction Value $17.00, up $0.05

The **Transaction Value** is **$17.00** per pound U_3O_8, **up $0.05** since last month. The calculation includes 23 transactions involving a total of 4.9 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value $1.80, unchanged

The **Conversion Value** is **$1.80** per pound U as UF_6, **unchanged** since last month. Active secondary market supply for conversion services for delivery within three years totals **580** thousand pounds U as UF_6. Active demand totals **one million** pounds U as UF_6. **One** secondary market conversion transaction is reported.

SWU Value for delivery within one year: $77, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **$77** per SWU, unchanged since last month. **Three** secondary market SWU transactions are reported

* * *

Analysis and Commentary

Nuexco's five-year uranium production forecast shows a slight increase in production under free market conditions, from 96 million pounds U_3O_8 in 1986 to approximately 98 million pounds by 1990. If US utilities were forced to use at least 50 percent US-origin uranium, US production would rise to about 18 million pounds in 1990, a 30-percent increase over the 1986 total of 13.8 million pounds U_3O_8. If that required percentage of US-origin consumption were increased to 75 percent, annual US output would rise to 25 million pounds by 1990.

Raw Materials

By-product or co-product uranium constitutes a significant part of the world uranium resource base. For example, nearly all of South Africa's uranium is produced as a by-product of gold mining. By-product uranium is mainly produced from quartz-pebble conglomerates (South Africa), and from phosphates (USA and USSR), but also may be produced from multi-mineral ores, black shales, mine water, lignites, and seawater. This article examines the spectrum of by-product uranium operations and technologies.

Japan

Several Japanese utilities may begin construction of as many as nine new nuclear units by the end of fiscal year 1988, totaling over 9,600 MWe of capacity, to meet forecast demand increases for electric power.

South Africa

First-quarter 1987 uranium output from South Africa's Chamber of Mines producers has declined 2.4 percent from the last quarter of 1986, totaling 2.71 million pounds U_3O_8. Substantial drops in production at Buffelsfontein, Harmony and Randfontein accounted for much of the decrease.

This Executive Summary may be reproduced for internal distribution.

© NUEXCO 1987

NUEXCO

NUEXCO REPORT 225 FIGURES OF THE MONTH (April 30, 1987)	This Month (Report 225)	Last Month (Report 224)	12 Months Ago (Report 213)
Exchange Value[1]	17.00	17.00	17.25
Transaction Value[1]	17.00	16.95	17.10
UF_6 Value[2]	48.00	48.00	48.50
Loan Rate[3]	3%	3%	5%
Conversion Value[4]	1.80	1.80	1.90
Near-Term Uranium Supply[5]	4.5	3.5	2.6
Near-Term Uranium Demand[6]	0.6	1.8	1.2
Near-Term Supply-Demand Ratio	7.8	1.9	2.1
Recent Uranium Sales:			
Number of Transactions[7]	10	10	6
Quantity of Material[8]	4.1	2.2	1.4
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	77	77	90
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	455	455	467
3.0 w/o U_{235}	582	582	598
3.5 w/o U_{235}	711	711	731
4.0 w/o U_{235}	842	842	866

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used in the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (224)

Section	Topic	Page
Analysis and Commentary	Uranium Import and Export Licensing in the USA	12
Essay	Australian Politics and Australian Uranium: A Commercial Anachronism	15
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in March 1987	1
	Enriched Uranium and SWUs Pricing in March 1987	2

© NUEXCO 1987

CONTRACTING FOR URANIUM: AN ANALYSIS OF TRENDS IN TERMS AND CONDITIONS

NUEXCO is pleased to announce the availability of our report on contracting trends and practices within the uranium market. The report is a comprehensive analysis of historical trends and current practices in natural uranium contracting, including purchasing strategies of the various countries, and terms and conditions for new contracts and renegotiations. The report addresses the following areas in detail:

- Contract prices and pricing mechanisms
- Flexibilities in delivery schedules, quantities, location
- Termination clauses, force majeure issues, disputes
- Supply reliability
- Utility participation in production joint ventures
- Desired levels of strategic inventories
- General approach to contract negotiations or renegotiations
- Description of current uranium procurement practices
- Recommendations

For further information, please contact
Gene Clark or Treva King
at 303/893-4015.

NUEXCO

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 NUEXCO DVR

PROSPECTS FOR THE CANADIAN URANIUM INDUSTRY

By

O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto Canada

Presented
at the

Annual General Meeting
Canadian Institute of Mining and Metallurgy

Toronto, Ontario
May 5, 1987

© NUEXCO 1987

PROSPECTS FOR THE CANADIAN URANIUM INDUSTRY

By O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto, Canada

Dr. Runnalls, a resident of Toronto, Canada, worked for 20 years for Atomic Energy of Canada Ltd. until 1971, when he was appointed Senior Advisor, Uranium and Nuclear Energy in the Department of Energy, Mines and Resources in Ottawa. He also served for five years as Executive Vice President of Uranium Canada, Ltd. Since 1979, he has been associated with his alma mater, the University of Toronto, and presently is Chairman of the Centre for Nuclear Engineering. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

This paper was prepared and presented by Dr. Runnalls for the Annual General Meeting of the Canadian Institute of Mining and Metallurgy at Toronto, Ontario on May 5, 1987.

Introduction

Since the phenomenon of nuclear fission was discovered in 1938, the utilization of uranium has grown substantially. Initially, the principal use for uranium was in the production of nuclear weapons. However, once civilian nuclear power reactors began to be built in the 1950s, an increasing fraction of uranium output was directed to the production of fuel elements for use in electricity generating stations.

The cumulative uranium production by those countries in the World Outside Centrally-Planned-Economies Areas (WOCA) during the period 1938-1985 exceeded 800,000 tonnes uranium. Some 60 percent of that was mined in the United States and Canada (Figure 1). In 1986, nearly 80 percent of WOCA output came from five countries, Canada, USA, South Africa, Australia, and Namibia, as shown in Table 1 and Figure 2.

During the past decade the world annual consumption of nuclear energy has more than tripled (Figure 3). As of December 31, 1986, the world total of nuclear power reactors had reached 394, with a total net capacity of 270 GWe(6). The thermal output from nuclear power plants in 1985 exceeded 60 percent of the energy contained in all of the oil produced that year in the Middle East. Thus, nuclear power has already become an important component in the world energy supply picture.

Table 1

URANIUM PRODUCTION FROM WOCA COUNTRIES(2,3)

	Output (1,000 tonnes U)	
Country	**1985**	**1986 (estimated)**
Canada	10.9	11.7
United States	4.2	5.5
South Africa	4.8	4.7
Australia	3.3	4.2
Namibia	3.5	3.5
France	3.2	3.1
Niger	3.2	3.1
Gabon	0.9	0.9
Others	0.5	0.5
Total	34.5	37.2

Future Growth

Estimates of future growth of the industry have been published recently by the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) for WOCA countries(1,7). Such estimates indicate that installed capacity of and electricity generation from nuclear plants could double by 2000. Longer range forecasts to 2025 using low and high projections reveal a large uncertainty by 2025 (Figure 4). The uncertainty alone in 2025 is nearly four times the 1986 installed capacity. There has been a tendency in recent years to discount future estimates for nuclear plant construction because of the inaccurate predictions of the past. During the 1970s forecasts of future capacity were over-optimistic but by the 1980's the earlier optimism had been modified appreciably.

Annual uranium requirements must rise to meet the growing numbers of reactors in operation and under construction. Requirements as estimated by the NEA and IAEA recently(1) are shown in Figure 5. The cumulative needs for the period 1985-2025 are plotted in Figure 6 for both high and low projections and for two reactor strategies, one employing light water reactors (LWRs) and the other if fast-breeder reactors (FBRs) are introduced in appreciable numbers in the 1990s. One concludes that with either strategy, severe stress will be placed on the world's uranium resources within a few decades.

© NUEXCO 1987

Figure 1

CUMULATIVE URANIUM PRODUCTION BY WOCA COUNTRIES 1938-1985 IN TONNES U (1,2)

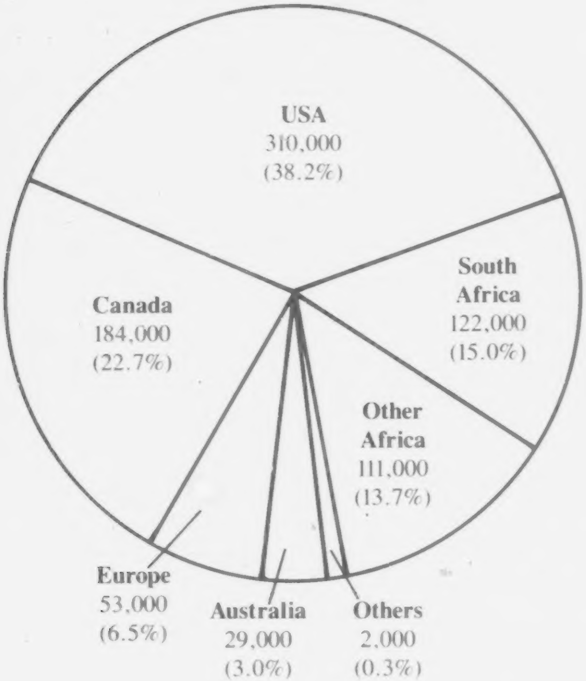
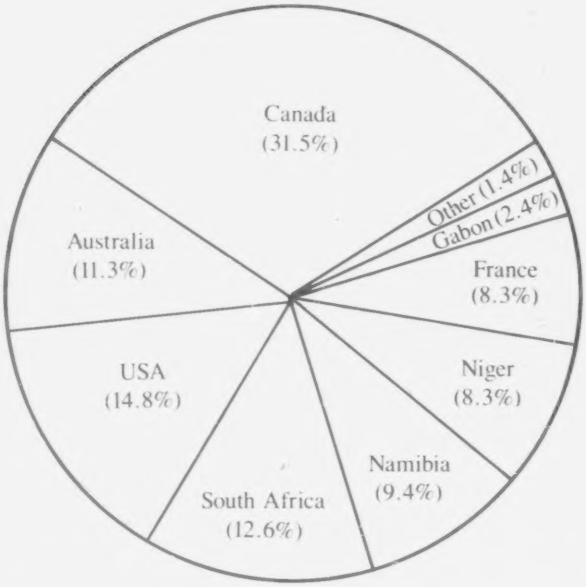


Figure 2

SHARES OF 1986 URANIUM PRODUCTION BETWEEN WOCA COUNTRIES (2,3)



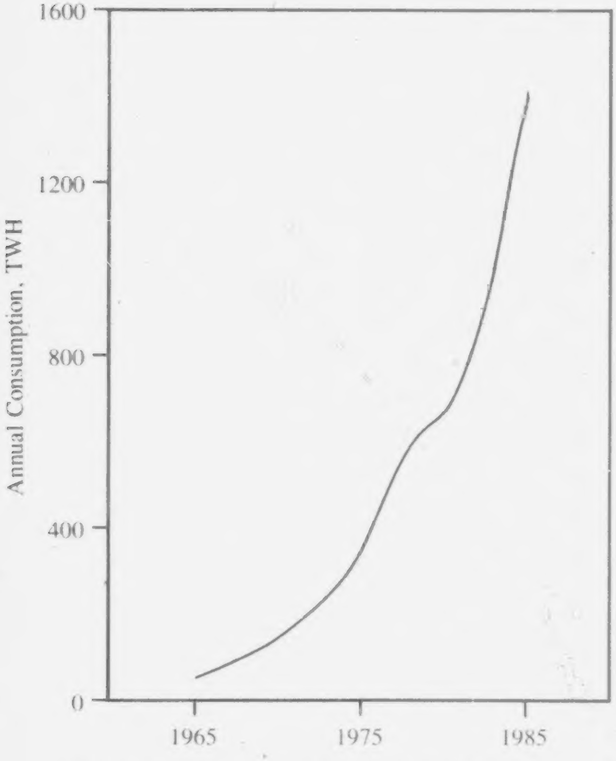


Figure 3. World Annual Consumption of Nuclear Energy (4,5,6)

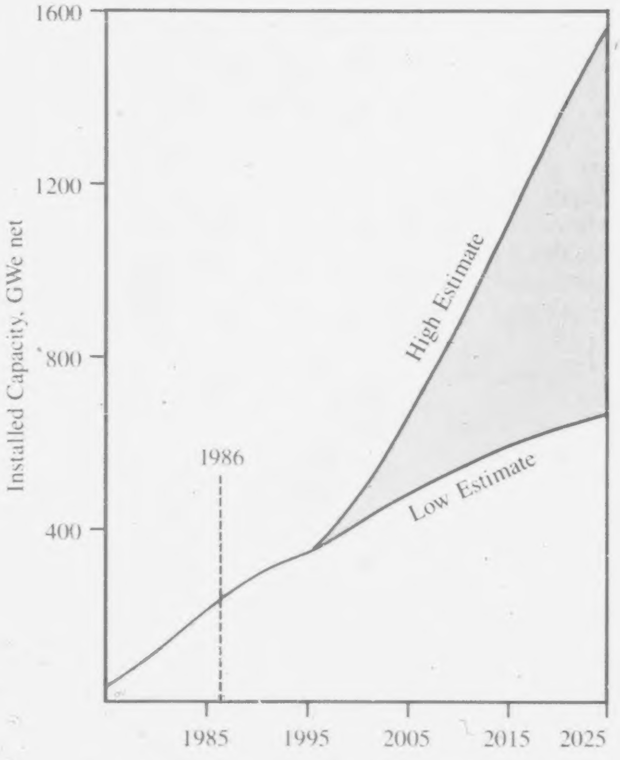


Figure 4. Nuclear Generating Capacity in WOCA Countries (1,7)

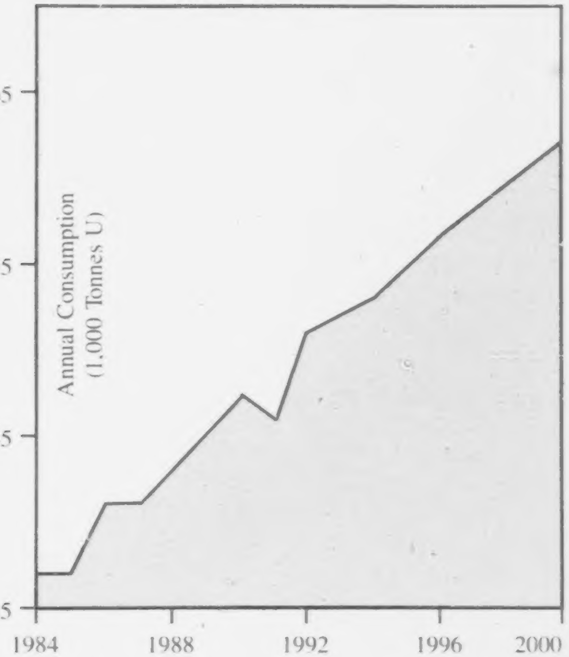
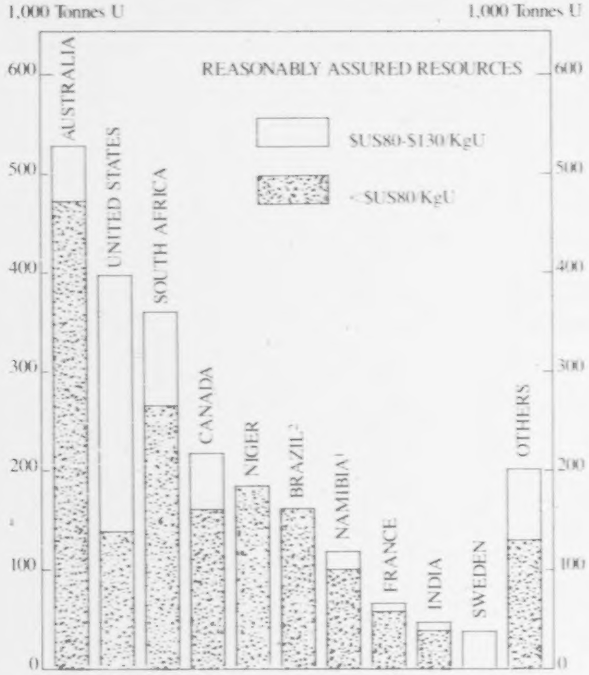


Figure 5. Annual Uranium Requirements for WOCA Countries(2)

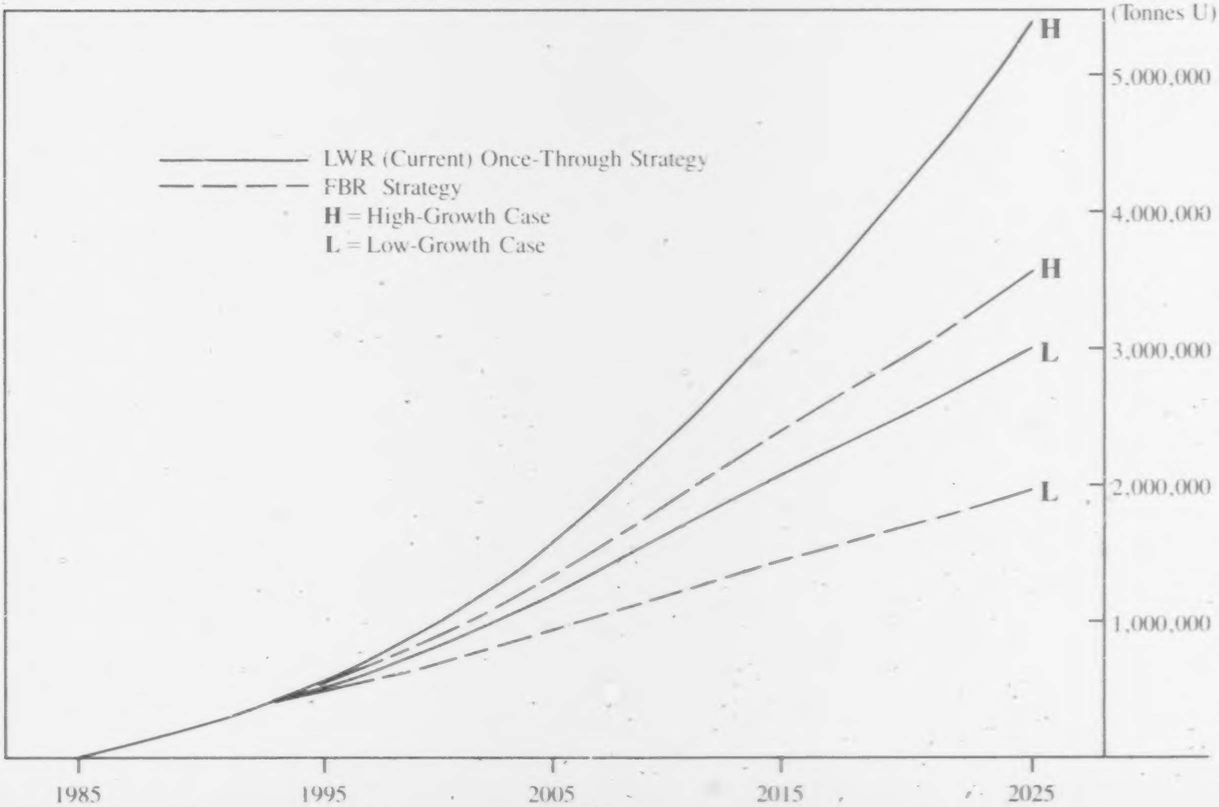


1. OECD (NEA)/IAEA: Uranium Resources, Production and Demand, Paris, 1983, adjusted for production and estimated production.
2. In situ resources.

Figure 7. Distribution of Uranium Resources among WOCA countries(1)

Figure 6

ILLUSTRATIVE LONG-TERM PROJECTIONS OF RANGE OF CUMULATIVE REACTOR-RELATED URANIUM REQUIREMENTS(1)



Uranium Resources and Production

According to the NEA/IAEA(1), Reasonably Assured Resources in WOCA countries recoverable for up to $US 130 per kilogram U, some three times the current spot market price, total 2.3 x 10^6 tonnes U (Figure 7). The foreseen rise in uranium consumption has led analysts such as Frisch(8) to predict that the exhaustion of proven uranium reserves could spread contagiously to the whole world between 2010 and 2015. Such projections run counter to the widely-held belief in the nuclear industry that the current surfeit of low-priced uranium will persist for the foreseeable future.

It is now appreciated that for most of the past two decades WOCA production has considerably exceeded requirements, as shown in Figure 8. That situation has been reversed for the past two years. Nonetheless, enough stockpiles have been accumulated since the mid-1960s to provide fuel for existing reactors for perhaps the next three or four years(1). The presence of such inventories overhanging the market coupled with the conviction of nuclear power plant owners that uranium will be available in abundance for the long term have resulted in a substantial drop in the world market price, which had peaked in 1979. The spot market price, for example, decreased by more than three-fold between 1979 and 1987 when measured in constant dollars. Such downward pressure on prices has had a profound effect on the uranium production industry, particularly that in the USA. Output from US mines dropped by four-fold between 1980 and 1985 as many high cost mines were forced to close in the face of falling prices.

Meanwhile, mining from the rich, newly-discovered Canadian deposits in the Athabasca Sandstone region of northern Saskatchewan had grown, so that Canada became the world's largest uranium producer beginning in 1984. Strong pressures have been exerted by the US uranium industry and by sympathetic politicians from the mining states in the midwestern USA to limit imports of uranium into the country. An important decision is expected soon from the US Tenth Circuit Court of Appeals in the Uranium Producers of America vs. US Department of Energy (DOE) lawsuit, which was filed, among other reasons, to prevent non-US-origin uranium from being processed in DOE enrichment plants until it can be demonstrated that the domestic uranium industry has recovered from its current non-viable state. Since the USA consumes about 30 percent of the uranium produced by WOCA countries, any import restrictions into that country would have a negative impact on outside producers such as Canada. One of the likely consequences would be the development of a two-tiered pricing structure with domestic American production commanding a higher price within the USA.

The possibility of a three-tiered structure exists as well because of the promulgation of the Anti-Apartheid Act of 1986 by the US Congress. One of the effects of the passing of this legislation, and of possible additional restrictive actions by members of the US Congress, will be to stop all imports of uranium of South African origin into the USA. In a world of few exporters these various moves by the USA could have an appreciable effect on the world market.

There has been some speculation that the Chernobyl nuclear reactor accident of April 1986 might have a large impact on annual uranium consumption. However, few countries have modified significantly their reactor programs in the months following the accident, and it now seems that any reduction in uranium consumption will be of only second-order effect, perhaps up to 5 percent overall.

Other factors leading to lower uranium consumption are the development of higher burn-up fuel, improved fuel management, and new fuel designs. Because of such developments, uranium demand in the USA, for example, could show a net decrease of some 6-7 percent by 2000. The resulting decrease in consumption is likely to be countered, however, by an increase resulting from increasing capacity factors in existing generating stations(9).

As mentioned earlier, a conviction has developed amongst WOCA countries during the past few years that uranium will continue to be available in abundance. This is reflected in appreciable reductions in exploration budgets, as illustrated in Figure 9. One could conclude that the stage is being set for a resurgence of the uranium supply industry in the 1990s to meet possible shortages.

What is often not appreciated by nuclear power plant owners is that the lead-times required to find and bring into production new uranium deposits can be longer than those needed to initiate, construct and commission a new nuclear power facility. The history of the development of the rich Key Lake mine in northern Saskatchewan is a case in point where even in a geologically-promising area in a stable and friendly country, the elapsed time between launching exploration, discovering a commercial uranium deposit, and achieving first output was fifteen years(10).

According to the NEA/IAEA, it is possible that within ten years additional production requirements, beyond those exisitng and committed and those planned and prospective, could be required (Figure 10). Given such estimates, it is timely that the Cigar Lake Mining Corporation should be moving ahead positively to bring into production its extremely rich uranium deposit in northern Saskatchewan by 1993(11).

© NUEXCO 1987

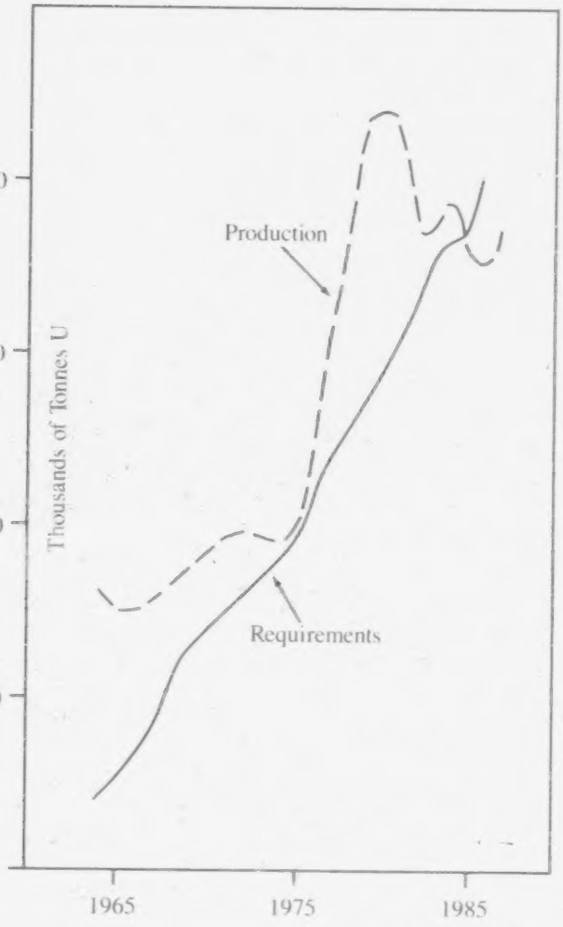


Figure 8. WOCA Uranium Production and Requirements, 1964-1986(1,2)

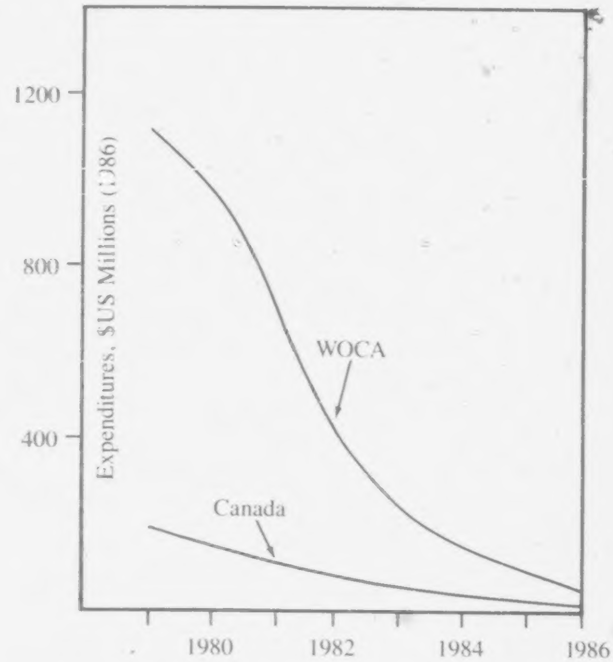


Figure 9. WOCA Uranium Exploration Expenditures(1,3)

The Canadian Uranium Industry

Meanwhile, in the midst of the currently uncertain market, the Canadian uranium mining industry has maintained a profitable position. Canada's five primary producers reported a total output in 1986 of 11,720 tonnes U(3).

Although the Elliot Lake deposits in northern Ontario are relatively low in grade, they are massive in nature and the two companies mining in the area, Denison Mines Limited and Rio Algom Limited, have operated profitably there for many years. Both producers benefit from long-term supply contracts with domestic utilities and foreign customers. Some of these purchase commitments extend well into the next century.

Uranium shipments from Ontario producers were valued at $476 million in 1986, somewhat higher than the $447 million of product shipped from Saskatchewan(3). The output from Ontario, however, was lower than that from Saskatchewan, being 43 percent of total production.

There are three operations in northern Saskatchewan, as follows:

1. Key Lake Joint Venture — owned by Saskatchewan Mining Development Corpration (SMDC[1], 50%), Uranerz Exploration and Mining Limited (UEM[2], 33.3%), and Eldor Resources Limited (16.7%).
2. Rabbit Lake and nearby properties — owned by Eldorado Resources Limited.
3. Cluff Mining — owned by Amok Ltd.[3] (80%), and SMDC (20%).

Eldor Resources Limited and Eldorado Resources Limited are both subsidiaries of Eldorado Nuclear Limited, a federally-owned crown corporation. Eldorado Resources operates a uranium refinery at Blind River, Ontario, and a chemical conversion plant at Port Hope, Ontario to produce ceramic-grade uranium dioxide (UO_2) powder for CANDU reactor fuel fabrication, and uranium hexafluoride (UF_6) for export abroad to uranium isotope enrichment facilities.

---

[1] SMDC is a crown corporation owned by the province of Saskatchewan.

[2] UEM is a subsidiary of Uranerzbergbau, Bonn, West Germany.

[3] Amok is owned entirely by French interests.

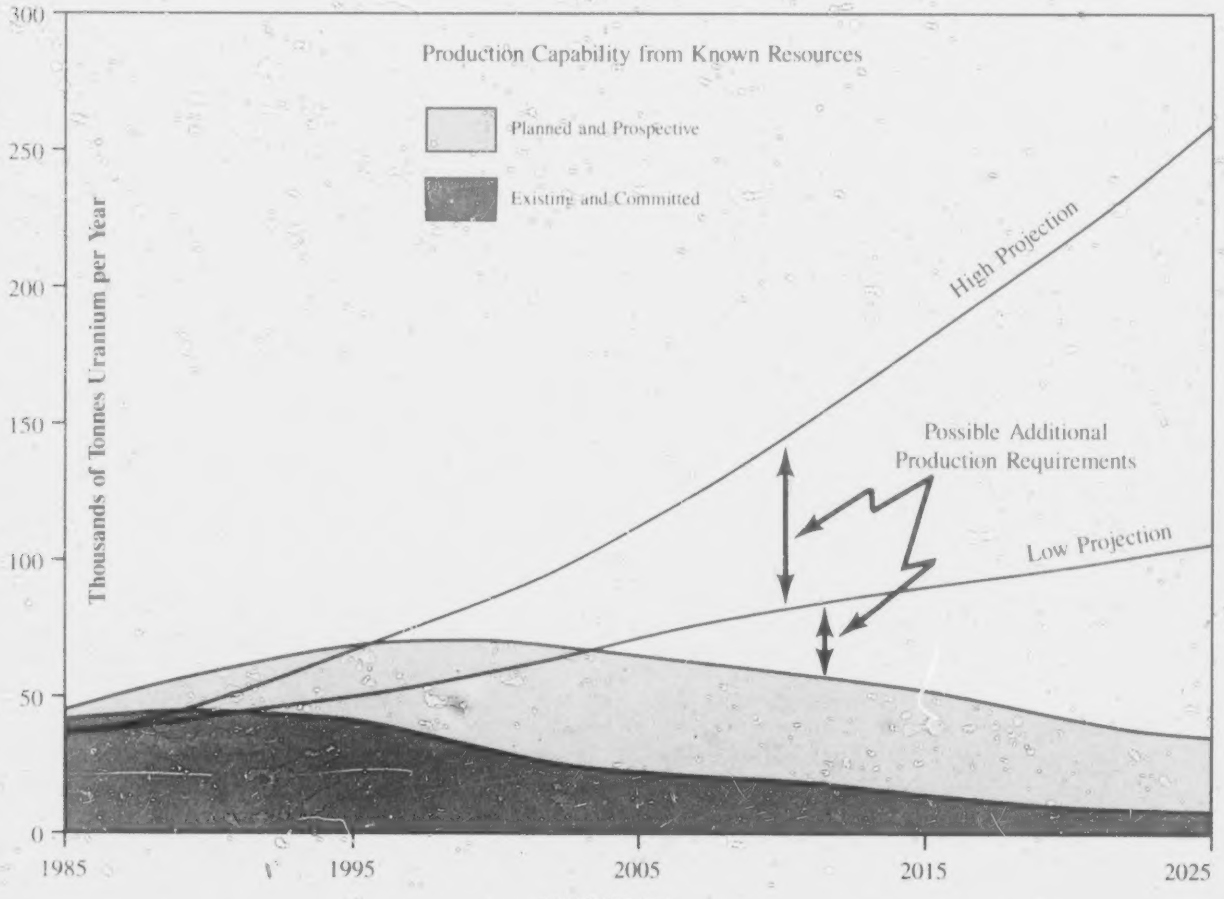
The federal government issued a policy in 1974 stating that unless a specific exemption was issued by the regulatory agency, the Atomic Energy Control Board, uranium would have to be upgraded to the most advanced form possible in Canada before export approval would be granted(12). In effect, this meant that uranium concentrates would have to be converted to UF_6 in the only facility available, Eldorado's, prior to export. The USA recently took issue with this upgrading policy, after it had been in operation for more than a decade, and filed a formal protest under the General Agreement on Tariffs and Trade, (GATT)(13). The charge is that the policy is inconsistent with Article XI of GATT, which forbids export restrictions.

Eldorado's problems were further compounded in late 1986 when the Canadian government announced as part of its anti-apartheid measures that no uranium of South African origin in any form would be allowed into Canada, even if it was merely in transit for processing and re-export by Eldorado.

The federal government's clear intention after nearly three years of sales efforts is still to dispose of Eldorado Nuclear Limited to outside investors. To facilitate this process, the government of Canada transferred the ownership of its Eldorado shares in January, 1983 to another crown-owned firm, the Canada Development Investment Corporation(14), which currently is engaged in developing possibilities for Eldorado's sale.

Figure 10

WOCA URANIUM PRODUCTION CAPABILITY AND REACTOR-RELATED REQUIREMENTS, 1985-2025(2)



©NUEXCO 1987

Future Prospects

The deposits being exploited in Saskatchewan are some of the world's richest. Many are near-surface and can be recovered using open-pit techniques. The Cigar Lake deposit, however, is located at a depth of some 430 metres between the overlying sandstone and the underlying metamorphic gneisses. Fortunately, the ore is very rich. The total ore reserve estimate for the deposit stands at 150,000 tonnes U(11). This is sub-divided between two regions, the main pod zone and the western extension. Reserves in the former mineralized area total 110,000 tonnes U averaging 12 percent uranium. The western extension contains inferred reserves of 40,000 tonnes U in ore averaging 4 percent uranium(11). By comparison, the Elliot Lake ores currently being mined from a depth of some 1,000 metres assay at about 0.1 percent uranium.

Other ore discoveries with commercial potential have been found in Saskatchewan at Midwest Lake, Dawn Lake, McLean Lake, and Maurice Bay. Promising deposits have also been delineated at Lone Gull in the Northwest Territories and Blizzard in British Columbia. Development of these ore-bodies is likely to be delayed, however, until the mid-1990s or later because of current unfavourable market conditions.

The potential for future discovery is high, particularly in the western part of the country where most of the current exploration effort is being expended. Many countries with few indigenous uranium resources and growing nuclear programs are continuing to invest there in the search for new deposits.

One could predict that for many decades into the future, given the promising prospects for discovery and development as well as the present appreciable production base, Canada should continue to be an important uranium producer. The domestic nuclear reactor program will have first priority on any output. Currently that requirement is only about 15 percent of the total, however, so large tonnages are available for export. It is probable, therefore, that Canada will remain as an important supplier into the world market for many years to come.

References

1. *Uranium — Resources, Production and Demand*, OECD Nuclear Energy Agency and the International Atomic Energy Agency, Paris, 1986.
2. Unpublished data, *Uranium Institute*, London, January, 1987.
3. Whillans, R.T., "Uranium", *Canadian Mining Journal*, in press, March, 1987.
4. *Annual BP Statistical Reviews of World Energy*, British Petroleum Company, London, England, June, 1986 (and earler).
5. *Nucleonics Week*, McGraw-Hill Inc., New York, Vol. 28, February 5, 1987: 9.
6. *IAEA Newsbriefs*, International Atomic Energy Agency, Vienna, Vol. 2, No. 2, February 10, 1987: 2.
7. *Summary of Nuclear Power and Fuel Cycle Data in OECD Member Countries*, OECD, Paris, April, 1986.
8. Frisch, J.R., *Future Stresses for Energy Resources*, World Energy Conference Conservation Commission, 13th Congress of the World Energy Conference, Cannes, France, October 11, 1986.
9. *Nuclear Fuel*, McGraw-Hill Inc., New York, Vol. 11, No. 19, September 22, 1986: 7.
10. Runnalls, O.J.C., *Key Lake: A Model of Canadian Development*, Proceedings, Deutsches Atomforum Winter Meeting, Bonn, Federal Republic of Germany, January 27-28, 1987.
11. Peebles, G.A., and J.M. Potier, *Mining the Cigar Lake Uranium Deposit*, Uranium Institute Eleventh Annual Symposium, London, September 2-4, 1986.
12. MacDonald, Hon. D.S., *Statement on Canada's Uranium Policy*, Ottawa, Ontario, September 5, 1974.
13. *Nuclear Fuel*, McGraw-Hill Inc., New York, Vol. 12, No. 1, January 12, 1987: 1.
14. Eldorado Nuclear Limited, Ottawa, Ontario, *Annual Report*, 1983: 9.

© NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

May 1987 No. 225

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

ANALYSIS AND COMMENTARY

Five-Year World Production Forecast 13

RECENT DEVELOPMENTS

Japan 19
South Africa 20

RAW MATERIALS

By-Product and Co-Product Uranium Resources and Production 21

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 29
Historical Exchange Values and Transaction Values 30
Historical Conversion Values and UF₆ Values 31
Graph of World Uranium Production 32
US Uranium Marketing Activities Statistics 33
Volume and Price of Uranium Deliveries to the European Community 34

GOVERNMENT STATISTICS

Australia 35
Canada 36
South Africa 37
United States 38

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

NUEXCO

PRICING

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of April 30, 1987)

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **4,495,000** pounds U_3O_8 equivalent, up one million pounds since last month. The corresponding figure for **active demand** is **575,000** pounds, down 1,225,000 pounds. The spot and near-term **supply-demand ratio** increased to **7.8 to 1.**

The *Current Market Data* section of this Report lists seven natural uranium concentrate sales, and one sale of natural UF_6, totaling 3.8 million pounds U_3O_8 equivalent. Two transactions involving low-enriched UF_6 are reported, totaling 300,000 pounds equivalent U_3O_8. US-origin uranium is commanding a premium (relative to the Exchange Value) of $1.50 per pound U_3O_8 (unchanged) in the form of concentrates, and $3.00 per kilogram U (down $0.50) in the form of UF_6.

The **Transaction Value** is **$17.00** per pound U_3O_8, up $0.05 since last month. The calculation extends over a 3-month period and includes 23 transactions involving 4.9 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$48.00** per kilogram U in UF_6, unchanged since last month. There remains a substantial spread between prices that discretionary UF_6 buyers are willing to pay and those that sellers will accept.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 580 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value remained at $17.00 this month, as several large spot transactions were concluded near this price, both by US and European utilities. These sales have removed much of the firm demand from the market, leaving mainly discretionary buyers. Supply, however, increased as substantial new quantities were made available. The reduction in demand and the coincident increase in supply have resulted in an increase in the supply-demand ratio since last month. Two long-term sales to US utilities totaled over 2.5 million pounds, while two other buyers concluded large spot purchases. Altogether, more than 4 million pounds U_3O_8 equivalent were sold during April.

The limitations and uncertainties caused by the Anti-Apartheid Act of 1986 in the USA, the still unresolved US Producers vs. DOE lawsuit, the Canadian upgrading policy, and non-proliferation restrictions on end use have fragmented the uranium market. Several factors point to origin and physical location as the prime considerations in price determination:

1. Substantial premiums for US-origin;
2. Smaller, occasional premiums for central African and other origins without certain types of end-use restrictions;
3. Frequent discounts for southern African-origin uranium;
4. The increasing desire by some US utilities to buy uranium that can be certified to have been produced in the USA, rather than US-origin material obtained by means of a flag swap.

Historically, swaps have been used to reduce or eliminate transportation costs and to expedite transactions. The primary reasons behind the increase in swap activity over the past year have been the wish to avoid certain national origins, the desire to profit from premiums associated with other origins, and the need or desire to circumvent prohibitions on physical delivery of specific origins or forms.

Uncertainties surrounding the position of the US Nuclear Regulatory Commission (NRC) in approving swaps of material being held at different licensee facilities lately have served to undermine the potential viability of swap transactions. Until recently, the NRC has essentially implied consent over swaps that may or may not have fallen under NRC jurisdiction. That position has changed somewhat, in that the NRC now appears to be withholding judgment, rendering neither approval nor disapproval.

De jure sanctions against importation of southern African uranium into the USA, and similar *de facto* sanctions imposed by other countries have constrained virtually all buyers in North America and some in Europe from taking delivery of southern African material. However, substantial quantities of discount-priced uranium from southern Africa have been made available selectively to those few buyers able to take advantage of that origin, either by accepting that material directly or by accepting material swapped for the southern African-origin material. Although nominal transaction prices may be near Exchange Value, extended payment terms and other inducements tend to reduce substantially the *effective* price of such material. One transaction reported this month involves a large quantity of southern African U_3O_8

© NUEXCO 1987

bought through such an arrangement, and considerably more material may be available.

In addition to one spot sale of US-origin uranium to a US utility, two long-term sales of US-origin also were concluded in April, with prices related to future market values. The premium (relative to the Exchange Value) for US-origin concentrates is unchanged at $1.50. In recent months, swaps have been the primary vehicle by which US-origin uranium is procured, and the premium (i.e. the incremental price commanded by US-origin material in transactions where the buyer restricts the acceptable origin to US) plus the Exchange Value has been less than the prices offered by US producers for their US-origin material.

Although US producers had been holding back from the market in anticipation that the Tenth Circuit Court of Appeals would quickly resolve the US Producers vs. DOE lawsuit, financial pressures have forced some US producers to compete more aggressively for available market opportunities. Producers' asking prices have declined recently, in some cases to a level approximately equal to the sum of the Exchange Value and the US premium. A resolution favorable to US producers still would likely cause a substantial increase in prices for US-origin, but until then, the short-term outlook for the US-origin premium is unclear. Much of the demand for US-origin for spot or near-term delivery has been filled over the past year, and the intense motivation by a number of utilities to procure US-origin has begun to subside. Many utilities have optimized origin status within their inventories through swaps and, consequently, feel little immediate pressure to add more US-origin uranium to their stocks.

Canadian sellers have not noticeably altered their asking prices in order to make spot sales. One large sale was made this month by a Canadian producer to a US utility. Although the contract price reportedly was close to the Exchange Value, the *effective* price, reflecting payment terms and conditions, was well below the contract price.

The UF_6 Value remained unchanged this month, at $48.00 per kgU as UF_6. One transaction reported this month involved natural UF_6, and two sales of low-enriched UF_6 are reported; altogether these transactions total less than 500,000 pounds U_3O_8 equivalent. These sales have removed some UF_6 demand from the market. Canadian sellers' aggressiveness in pursuit of available sales opportunities has lessened in recent months. At present, US-origin UF_6 appears to be relatively more abundant than US-origin U_3O_8, causing a slight decline in the premium (relative to the UF_6 Value) for US-origin UF_6 to $3.00 per kgU, down $0.50 since last month.

* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported. Both demand and activity in the market for loans have been small, often due to the security requirements imposed by most lenders.

* * *

The Conversion Value is unchanged since last month at $1.80. One small secondary market conversion sale is reported, but the secondary market for conversion services remains relatively inactive. Although demand has increased since last month, it remains highly discretionary.

ENRICHED URANIUM AND SWUS

The SWU Value remained at $77 per SWU this month. Three SWU transactions, totaling less than 100 thousand SWU, are reported in the *Current Market Data* section of the Report. There is some uncertainty in the SWU market, resulting from DOE's apparent willingness to adjust the enrichments of enriched product inventories to conform with the levels required by SWU buyers. Such a policy would reduce or eliminate the need for virgin or upgrade SWU, and tend to reduce or eliminate the premium that such upgrade SWU have commanded.

There is speculation that substantial additional SWU supplies, some in the form of enriched product, may soon be available from sources that have not previously been sellers. Thus, while the market has not yet been affected, the prospect of additional SWU supplies becoming available could lead to downward pressure on prices.

Separately, DOE has announced that its new SWU price under the Utility Services contract for FY88 (effective October 1, 1987) is $117 per SWU.

© NUEXCO 1987

CURRENT MARKET DATA

April 30, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**\$17.00**/lb. U_3O_8	4,495	575
UF_6 VALUE	**\$48.00**/kgU		
CONVERSION VALUE	**\$1.80**/lb. U as UF_6	580	1,000
SWU VALUE 0.3 tails assay: delivery within one year	**\$77**/SWU		
LOAN RATE	**3%**/annum	1,000	500

	\$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.00**	4.9	23	3

---

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1987

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**
Australia (dollar)	26.15	24.16	23.31	67.97	62.82	60.60
Belgium (comm. franc)	631.50	633.86	762.95	1,642	1,648	1,983
Canada (dollar)	22.73	22.22	23.79	59.09	57.77	61.84
EEC (ecu)	14.72	14.80	17.44	38.26	38.47	45.35
Finland (markka)	74.46	75.35	84.98	193.59	195.91	220.92
France (franc)	101.49	101.86	119.46	263.86	264.81	310.57
FRG (mark)	30.45	30.54	37.51	79.16	79.39	97.51
Italy (lira)	21,778	21,862	25,723	56,618	56,837	66,875
Japan (yen)	2,366	2,484	2,893	6,152	6,457	7,521
Netherlands (guilder)	34.39	34.57	42.28	89.41	89.87	109.92
South Africa (rand)	34.03	34.07	35.46	88.48	88.57	92.18
Spain (peseta)	2,140	2,157	2,384	5,563	5,607	6,198
Sweden (krona)	106.65	107.32	120.88	277.27	279.02	314.27
Switzerland (franc)	24.96	25.48	31.37	64.88	66.24	81.55
UK (pound)	10.24	10.58	11.14	26.62	27.49	28.97
US (dollar)	17.00	17.00	17.25	44.20	44.20	44.85

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**
Australia (dollar)	26.15	24.09	23.11	67.97	62.64	60.08
Belgium (comm. franc)	631.50	631.99	756.30	1,642	1,643	1,966
Canada (dollar)	22.73	22.15	23.58	59.09	57.60	61.30
EEC (ecu)	14.72	14.76	17.29	38.26	38.36	44.56
Finland (markka)	74.46	75.13	84.24	193.59	195.33	219.00
France (franc)	101.49	101.56	118.42	263.86	264.03	307.87
FRG (mark)	30.45	30.45	37.18	79.16	79.16	96.66
Italy (lira)	21,778	21,798	25,500	56,618	56,670	66,293
Japan (yen)	2,366	2,476	2,868	6,152	6,438	7,455
Netherlands (guilder)	34.39	34.47	41.91	89.41	89.60	108.96
South Africa (rand)	34.03	33.97	35.15	88.48	88.31	91.38
Spain (peseta)	2,140	2,150	2,363	5,563	5,590	6,144
Sweden (krona)	106.65	107.01	119.83	277.27	278.20	311.54
Switzerland (franc)	24.96	25.40	31.10	64.88	66.05	80.84
UK (pound)	10.24	10.54	11.05	26.62	27.41	28.72
US (dollar)	17.00	16.95	17.10	44.20	44.07	44.46

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1987.

© NUEXCO 1987

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**	**This Month (Apr 30, 1987)**	**Last Month (Mar 31, 1987)**	**12 Months Ago (Apr 30, 1986)**
Australia (dollar)	2.77	2.56	2.57	6.10	5.64	5.66
Belgium (comm. franc)	66.86	67.11	84.03	147.41	147.96	185.26
Canada (dollar)	2.41	2.35	2.62	5.31	5.19	5.78
EEC (ecu)	1.56	1.57	1.92	3.44	3.45	4.24
Finland (markka)	7.88	7.98	9.36	17.38	17.59	20.63
France (franc)	10.75	10.78	13.16	23.69	23.78	29.01
FRG (mark)	3.22	3.23	4.13	7.11	7.13	9.11
Italy (lira)	2,306	2,315	2,833	5,084	5,103	6,246
Japan (yen)	250.56	262.97	318.63	552.38	579.74	702.46
Netherlands (guilder)	3.64	3.66	4.66	8.03	8.07	10.27
South Africa (rand)	3.60	3.61	3.91	7.94	7.95	8.61
Spain (peseta)	226.56	228.34	262.58	499.47	503.40	578.88
Sweden (krona)	11.29	11.36	13.31	24.90	25.05	29.35
Switzerland (franc)	2.64	2.70	3.46	5.83	5.95	7.62
UK (pound)	1.08	1.12	1.23	2.39	2.47	2.71
US (dollar)	1.80	1.80	1.90	3.97	3.97	4.19

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU VALUE delivery within one year (April 30, 1987)**	**UF_6 Value per kg.U in UF_6 This Month (April 30, 1987)**	**UF_6 Value per kg.U in UF_6 Last Month (March 31, 1987)**
Australia (dollar)	118.43	73.82	68.23
Belgium (comm. franc)	2,860	1,783	1,790
Canada (dollar)	102.95	64.17	62.73
EEC (ecu)	66.67	41.55	41.78
Finland (markka)	337.28	210.24	212.76
France (franc)	459.70	286.56	287.59
FRG (mark)	137.92	85.97	86.22
Italy (lira)	98,642	61,491	61,728
Japan (yen)	10,718	6,682	7,012
Netherlands (guilder)	155.78	97.10	97.60
South Africa (rand)	154.15	96.09	96.19
Spain (peseta)	9,692	6,042	6,089
Sweden (krona)	483.06	301.12	303.03
Switzerland (franc)	113.04	70.46	71.94
UK (pound)	46.37	28.90	29.86
US (dollar)	77.00	48.00	48.00

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1987.

© NUEXCO 1987

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
4009	1987	101-300	101	Utility	Trader	
4017	1987	101-300	105	Trader	Utility	US-origin.
4020	1987	less than 50	102	R[5]	Producer	
4021	1990-94	101-300	see Remarks	Producer	Utility	US-origin. Price related to market.
4024A	1987	50-100	R[5]	Trader	Utility	Low-enriched UF_6.
4034	1989-95	1,501-3,000	see Remarks	Producer	Utility	US-origin. Price related to market.
4037	1987	301-600	99	Trader	Utility	
4038A	1988	101-300	R[5]	Trader	Utility	Low-enriched UF_6.
4039	1987	301-600	R[5]	Producer	Utility	
4040	1988	101-300	110	Trader	Utility	UF_6.

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Price are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g. X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

CURRENT MARKET DATA

Conversion Services Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
4036	1987	less than 50	94	Trader	R[5]	

Enrichment Services Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4023	1987	less than 50	100	Utility	Trader	Eurodif	
4024A	1987	less than 50	R[5]	Trader	Utility	USSR	Low-enriched UF_6.
4038B	1988	50-100	R[5]	Trader	Utility		Low-enriched UF_6.

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Price are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g. X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

URANIUM SUPPLY
(April 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale: ACTIVE			
2335	420	—	
2740	250	—	
2764*	500	—	UF_6
2893A	720	—	UF_6
2933	300	300 per year	1988-90
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121*	1,000	—	
3129	500	1,000	
3135*	200	—	
3166	50	—	
2263	—	400 per year	1989 on
2781*	—	400 per year	1988-95
2996	—	500 per year	1988-90
3123*	—	2,000	1988
3171	—	200 per year	1988-92
3244*	—	300 per year	1988-93
TOTAL:	4,495		
INACTIVE			
2297	100	100 per year	1988-89
2389	300	—	
2967*	1,000	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
TOTAL:	1,450		

---

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 3221.

© NUEXCO 1987

CURRENT MARKET DATA

URANIUM DEMAND
(April 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2984*	260	—	U_3O_8 and UF_6
3175*	90	—	UF_6
3192	50	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3137	—	4,800 per year	1993-97
3147	—	200	1988-92
3193	—	700 per year	1989,91,94,96
TOTAL:	575		
INACTIVE			
2760	750	750 per year	1988-90
2798	150	—	
2911	65	—	UF_6
TOTAL:	965		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2987, 2991, 3120, 3209.

© NUEXCO 1987

LOAN SUPPLY AND DEMAND
(April 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
TOTAL:	1,000		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		
Inquiries to borrow			
ACTIVE			
3206*	500	—	
TOTAL:	500		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

© NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6)		Remarks
	Within 3 Years	Beyond 3 Years	
Available for Sale: ACTIVE			
2764B	500	—	
3222	80	—	
TOTAL:	580		
Available for Sale: INACTIVE			
2859	750	750	
2988	165	—	
3165	330	—	
TOTAL:	1,245		
Inquiries to Purchase: ACTIVE			
3120	1,000	700	1988-89
TOTAL:	1,000		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

© NUEXCO 1987

SWU SUPPLY AND DEMAND
(April 30, 1987)

Nuexco Project Number	Spot or Near-term[2]	Intermediate or Long-term	Remarks
	Delivery Period[1] (Thousands of SWUs)		
Available for Sale:			
ACTIVE			
2571	55	—	1987
2969	200	—	1987
3173*	45	—	1987
TOTAL:	300		
INACTIVE			
3213*	150	—	1987
3322*	150	—	1987
TOTAL:	300		
Inquiries to Purchase:			
ACTIVE			
2999	150	—	1987
3159	30	—	1987
TOTAL:	180		

*New or revised since last month

[1] Measured from the date of this Report

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts

Projects removed since last month: 3156, 3162

© NUEXCO 1987

ANALYSIS AND COMMENTARY

FIVE-YEAR WORLD PRODUCTION FORECAST

Introduction

The possibility of protectionist measures designed to aid the US uranium industry has altered Nuexco's projections of future uranium production worldwide. In this revised forecast, Nuexco discusses projections for three possible future scenarios:

1. Free Market — No significant governmental restrictions limiting the international trade of uranium;
2. 50-Percent US-Origin Requirement — US utilities are required to utilize US-origin uranium for 50 percent of their consumption;
3. 75-Percent US-Origin Requirement — US utilities are required to utilize US-origin uranium for 75 percent of their consumption.

The existing sanctions on the use of South African and Namibian uranium in the USA may have an additional effect on these supply scenarios.

For the free-market case, world uranium production is expected to increase slightly from the 1986 level of 96 million pounds to about 98 million pounds in 1990 (Table 1). Figure 1 shows the annual production forecast through 1990, by geographic producing region. This free-market case indicates a relatively stable uranium industry through 1990; however, a US market restriction, whether enforced by means of an enrichment limitation or an import restriction, could cause radical changes in market share held by several producing nations. Canada and Australia, in particular, would likely lose some market share to US producers.

Overview

Nuexco's forecast of world uranium consumption indicates a growth rate of only 1.8 percent per year from 1986 through 1990. As in the past, demand will be fulfilled by a combination of inventory drawdown, inventory redistribution and production. Nuexco's projection of world production is based on short-term, medium-term, and long-term economic and political considerations which affect both individual producers and the uranium production industry as a whole. In the short term, production will be primarily influenced by existing contracts as well as producers' perceptions of future market opportunities.

Uranium suppliers will continue to sell excess inventories in the spot market throughout the forecast period. This situation has prompted several other current or potential producers to cover at least some portion of their future delivery commitments with spot purchases from such selling producers. Uranium users will draw down portions of their excess uranium inventories to meet their unfilled uranium requirements. As inventory selling by utilities has essentially run its course, users will turn to traditional sources of supply, thereby stimulating additional production.

Table 1

WORLD URANIUM PRODUCTION FORECAST
(Millions of Pounds of U_3O_8)

Free Market Case

	1986	1987	1988	1989	1990
Australia	11	11	9	10	13
Canada	30	31	32	32	32
Central Africa[1]	10	10	10	10	10
France	8	8	8	8	8
Southern Africa[2]	21	20	19	18	18
USA	14	11	11	13	14
Other Countries[3]	2	2	2	3	3
Total	96	93	91	94	98

[1] Includes Niger and Gabon.
[2] Includes South Africa and Namibia.
[3] Includes Argentina, Belgium, Brazil, China, India, Pakistan, Portugal, Spain, and Yugoslavia.

In the longer term, supply/demand and price/cost market forces will tend towards equilibrium. This equilibrium process, however, will likely continue to be affected by political factors such as selective embargoes or sanctions, government-imposed minimum prices, and production controls. Depending on their nature, these factors can result in considerable short-term distortions of the marketplace.

Analytical Method

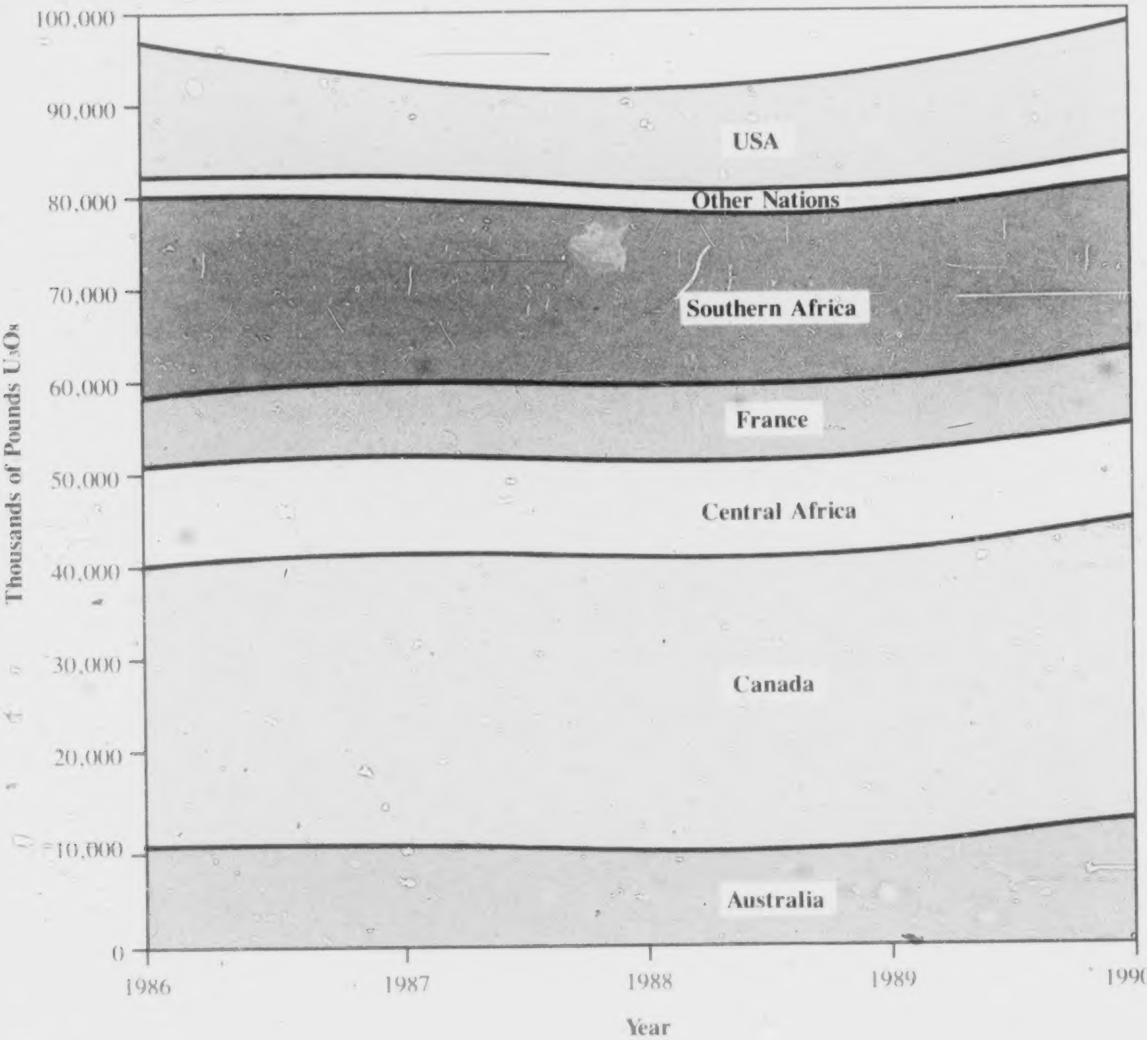
Nuexco's projection of world uranium production considers current production, announced plans for future changes in production, estimates by Nuexco of consumption on a worldwide basis, and other changes that Nuexco believes will affect producers. In the free-market case, Nuexco assumes that any political factors (embargoes, production restrictions, trade sanctions, minimum prices, and other government-induced controls) will have only minor impacts and that, in essence, a worldwide "free market" exists for the sale and use of uranium. For a given production center, the rate of production will be affected by four principal variables.

1. Production currently under contract;
2. Maximum production capability of the producing center;
3. Production costs anticipated for the center, especially relative to other production centers, and;
4. Political or institutional influences.

© NUEXCO 1987

Figure 1

FORECAST OF WORLD URANIUM PRODUCTION
FREE MARKET CASE



© NUEXCO 1987

The competition for new contracts and for spot-market sales for deliveries within the forecast period inherently favors the lower-cost producers with uncommitted production capacity. Nuexco's projection of world production considers both those producers that intend to add to or continue at relatively high production capacity and other producers that must cut back, discontinue, or postpone entering production.

Nuexco has analyzed variable and full costs of production for all world production centers, to determine which have the cost structure to remain or enter into the future market, giving due regard to the other factors which influence their decisions. Production costs can be affected to a significant degree by licensing and regulatory requirements, as well as by ore grade, royalties and taxes.

The imposition of new or more stringent uranium mining and milling regulations in Australia, Canada, and the USA has increased production costs and delayed many new projects, during periods favorable to marketing opportunities. These regulations range from worker safety to environmental impact, and affect mining, milling, tailings storage and disposal, transportation, and reclamation. New projects in the USA, Canada, and Australia have been subjected to the highest cost increases. Royalties and taxes also vary widely in those countries, with considerable variation occurring among provinces within Canada.

Nuexco also appraised a number of important political factors which could influence production within the forecast period:

1. Southern African (South Africa and Namibia) production is likely to be reduced as a result of the recent US law imposing an embargo on the importation of uranium from southern Africa. Additional reductions are possible if other nations or consumers decide to follow this same course of action.

2. Curtailment of Australian uranium production by action of the Labor Government is possible but not considered likely.

3. Production in the USA will be stimulated by any embargo or other type of restriction or limitation on the importation of non-US-origin material. Non-US production would be reduced by a similar amount.

4. Production in France and central Africa (Niger and Gabon) will likely remain stable regardless of the outcome of possible US market restrictions. Production in Spain could increase appreciably, depending on domestic political considerations.

Production Forecast for Three Scenarios

Nuexco has analyzed each individual production center from the standpoint of variable or full production costs, existing supply contracts, the potential to obtain new contracts, uranium reserve quantity and grade, the financial strength of the producer, and regulatory and other political influences of the host government. We then matched the unfilled requirements of the uranium users, plus their capability to absorb additional inventory, with the uncommitted production over the forecast period.

Free Market Case — Should a free-trade situation continue to prevail for the US uranium market, Nuexco forecasts the following trends:

1. Australian uranium production will increase by over 20 percent by 1990, to about 13 million pounds annually, as Australia begins its transition from an industry dominated by political considerations to one that is market-oriented. Nuexco believes that Australia is becoming less willing to constrain uranium production, and that the floor price and the government approval process will prove less difficult barriers to new projects and increased production.

2. Annual Canadian production may increase slightly through 1990, to about 32 million pounds. Undeveloped high-grade deposits in Saskatchewan will require long lead-times for commencement of operations and will not contribute to Canadian production during the five-year forecast period.

3. The largely captive domestic production in France is forecast to remain stable through 1990 at about 8 million pounds U_3O_8 annually.

4. Southern African (South Africa and Namibia) production is likely to decline during the forecast period as a result of the trade sanctions recently imposed by the USA, and by similar actions being taken elsewhere. Nuexco expects production from this geographic area to decrease about 13 percent, to 18 million pounds U_3O_8 in 1990. Should uranium embargoes against South Africa and Namibia become more widespread, an even greater reduction is possible.

5. Current US production is not highly competitive on a worldwide basis. However, the opening of several high-grade underground mines in New Mexico and Arizona, current by-product operations, and proposed solution mining projects could lead to a slight production increase reaching 14 million pounds annually by 1990. Much of this projected increase can be attributed to a desire by US utilities to buy US

© NUEXCO 1987

uranium, and to the desire of many foreign companies to participate, even at a small loss, in the US industry, in order to diversify their supply sources. Figure 2 shows Nuexco's forecast for US uranium production under the free-market scenario, and under restricted market conditions.

6. Uranium producers in central Africa (Gabon and Niger) may come under increasing pressure during the forecast period, due to the marginal economics of continued production from their low-grade deposits. This consideration is offset to some degree by a large component of captive production and by other concerns. Uranium production in these two countries is projected to remain approximately constant, totaling over 10 million pounds U_3O_8 in 1990.

7. A number of other countries, including Argentina, Brazil, Belgium, India, Pakistan, Portugal, Spain, and Yugoslavia, produce small quantities of uranium, primarily for use in their own nuclear programs. These countries are expected to maintain or increase their current production levels.

8. The People's Republic of China has recently entered the world uranium market with offers to sell U_3O_8 or UF_6. Their current production capability has been variously estimated at as much as 10 million pounds U_3O_8 per year, and there has been speculation that inventory could be as much as 80 million pounds U_3O_8. China could make available for sale during the forecast period as much as several million pounds U_3O_8 per year.

50-Percent US-Origin Requirement — Since the USA already faces the prospect of importing about half of its requirements within the forecast period, restrictions up to that percentage would not significantly affect the balance between US and non-US production.

Nuexco projects that in this case, US production would increase by about 4 million pounds to about 18 million pounds in 1990 (Figure 2), and that this increase would be fulfilled largely by a combination of reactivated conventional production from the Colorado Plateau, and by solution mining production from several new projects.

75-Percent US-Origin Requirement — Assuming that a 75-percent US-origin requirement is imposed on US utilities, there would immediately develop a surplus of production capacity for non-US uranium and a deficiency for US-origin uranium. Restrictions in excess of 50 percent of US requirements will affect a number of current and potential producers throughout the world. The greatest impact in terms of tonnage is likely to be upon Canada, which provides the largest portion of US imports and which has several high-cost, independent producers still in operation. Lesser effects would be felt elsewhere.

In the USA, a 75-percent embargo on the use of non-US-origin in US reactors would greatly stimulate domestic uranium production. Facilities currently on standby would be reactivated, solution mining projects currently under development would be completed earlier, and by-product uranium operations would experience a resurgence of production. Although some known higher-cost conventional uranium might be brought into production, the risks associated with large-scale, high-cost conventional production could be too high, and therefore many producers are likely to be more attracted to smaller, less capital-intensive projects. Nuexco forecasts that a 75-percent embargo on non-US uranium would result in an increase in US production of 74 percent, to about 25 million pounds U_3O_8 by 1990 (Figure 2).

The 50-percent US-origin requirement is projected to cause an increasing effect beginning in 1988, after a very slight increase in 1987. The 75-percent US-origin requirement produces an earlier and much larger effect.

Factors Influencing Production

Nuexco expects lower-cost production to continue displacing higher-cost production during the forecast period, even though much of the higher-cost production may currently be produced for delivery under existing contracts. Uranium produced from operating by-product recovery facilities is not at all sensitive to market price fluctuations, since the primary products determine the facilities' operating levels. However, startup of new by-product uranium recovery facilities is as sensitive to expectations of future market prices as are operations producing uranium as a primary product. High-cost, independent producers are likely to be forced from the future market should prices remain low. Under Nuexco's forecast:

1. Producers in the best position are those that can operate existing facilities or quickly startup new production facilities at a profit.

2. Producers whose existing facilities can produce uranium at costs equal to or below the market price, and thus recover some portion of their capital investment and interest charges, are likely to continue operation in the expectation of a better uranium market in the future.

3. Certain higher-cost producers operating below rated production capacity may elect to fulfill existing contracts from their own production facilities, but may be unable to produce economically for new contracts.

4. Producers who can improve their economic position by purchasing their future contract delivery requirements from

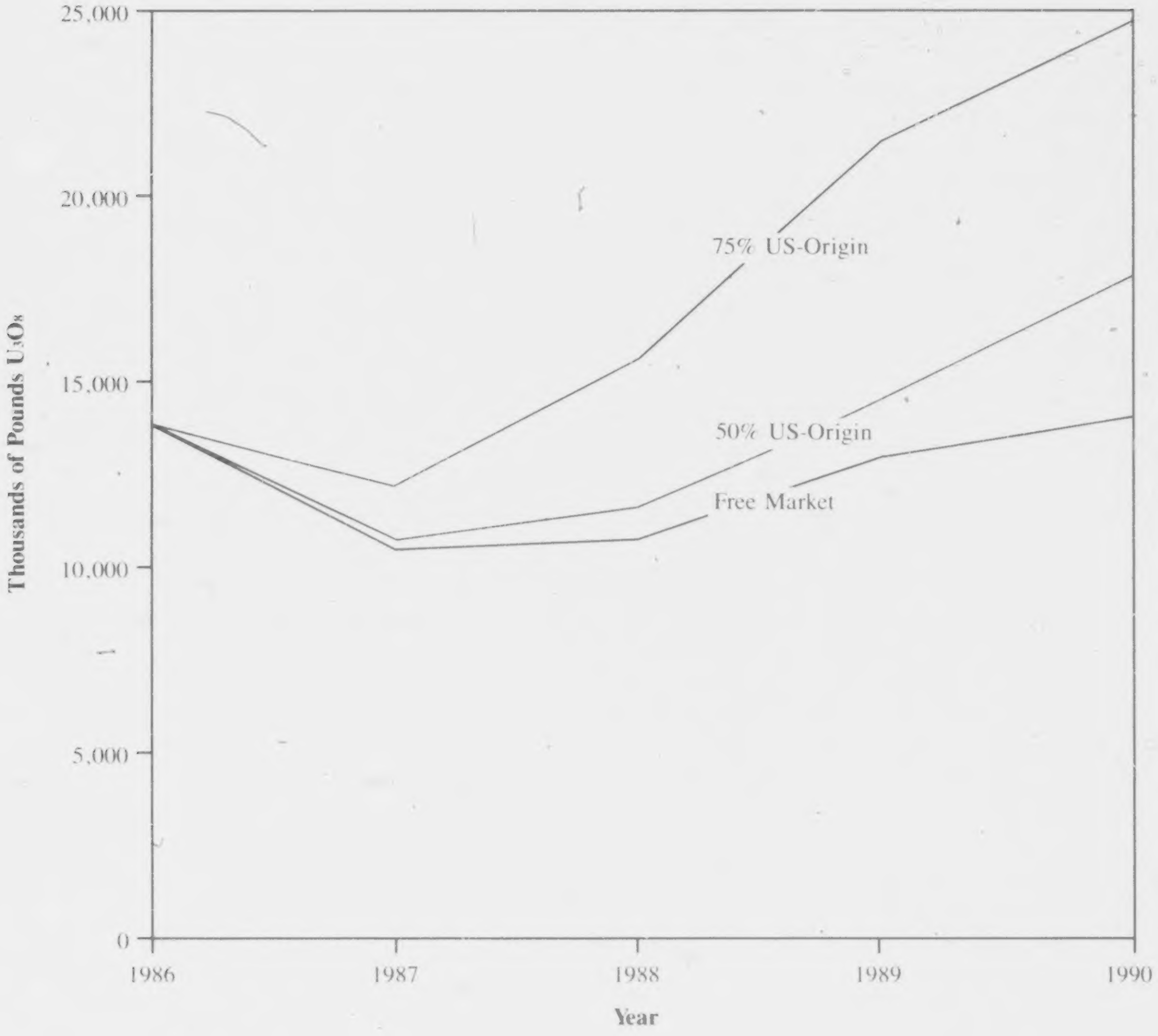
© NUEXCO 1987

NUEXCO

ANALYSIS & COMMENTARY

Figure 2

FORECAST OF US URANIUM PRODUCTION UNDER FREE-MARKET AND RESTRICTED-MARKET SCENARIOS



© NUEXCO 1987

inventory sellers or other producers may discontinue production or place their own facilities on standby.

5. Certain producers with extensive financial backing, whose losses are budgeted over a given time period, may elect to continue minimum production, even though it may be subeconomic to do so.

6. Some high-cost production centers which are captive to national entities or governments will, as a matter of policy, continue operation, despite poor economics.

7. Producers who recover uranium as a by-product of their major operations may have variable uranium production costs which are quite low; in those instances, they will continue by-product production as long as the combined production is profitable.

8. Producers with facilities on standby will return to the market when prices rise to a level that the producers believe will sustain operation at or near profitable levels.

Conclusion

Under the free-market scenario, annual worldwide uranium output would increase by only about two million pounds by 1990. Utilities' consumption of excess inventory material and producers' sales will provide approximately 20 percent of the required fuel during the five-year forecast period. Imposition of a 50-percent embargo on uranium imported into the USA for use in US reactors is projected to cause only a modest increase in US production. The 75-percent case, however, would immediately result in a surplus of production capacity for non-US uranium, and a deficiency in capacity for the US uranium production industry; production in the USA would increase by nearly 75 percent above the free-market scenario in 1990. Most other countries would experience a reduction in uranium output. In sum, a 75-percent US embargo would immensely stimulate US production, while creating a large shift in relative market share for virtually all of the world's other uranium producers.

© NUEXCO 1987

RECENT DEVELOPMENTS

JAPAN

In April 1987, Japan's Ministry of International Trade and Industry (MITI) released an outline of power facility construction plans for FY87 and FY88. This outline summarized plans submitted by several Japanese utilities to the Electric Power Development Coordination Council (EPDCC), and showed a vigorous plan for nuclear plant construction over the next several years (Table 2). EPDCC is the government organization that gives approval for planning; such approval allows the utility to apply for site licensing and construction permits. Despite reduced sales of electric power to industrial consumers in the past year, plans for the increase in nuclear construction are based on a projection that the annual increase in peak electric power demand could be as high as 2.8 percent through the mid-1990s.

Under the proposed plan, Tokyo Electric Power Company (TEPCO) would begin construction of Kashiwazaki-Kariwa Units 6 and 7 (1,355-MWe BWRs) during FY87 (which ends in March 1988), with commercial operation scheduled for 1996 and 1998 respectively. Earlier, the EPDCC had approved licenses for Kashiwazaki-Kariwa Units 3 and 4. License applications for these units were made in April 1985, and Unit 3 is expected to begin construction in June 1987.

Tohoku Electric Power Company applied to the EPDCC for approval to begin construction on Higashi Dori Unit 1 (1,100-MWe BWR) and Namie-Odaka (825-MWe BWR) during FY1988, which would begin commercial operation in 1997 and sometime after 1998 respectively. Tohoku also revealed preliminary plans for future construction of Totsu Unit 1, which could begin construction in 1991 or 1992. EPDCC had

Table 2

PLANNED NUCLEAR POWER PLANTS IN JAPAN

Unit Approved[1] Planned Units	Utility	Capacity (MWe Gross)	Type	COD[2]
Ohi 3	Kansai EPC[3]	1,180	PWR	Aug 1991
Ohi 4	Kansai EPC	1,180	PWR	Jun 1992
Noto 1	Hokuriku EPC	540	BWR	Mar 1993
Kashiwazaki-Kariwa 3	Tokyo EPC	1,100	BWR	Jul 1993
Kashiwazaki-Kariwa 4	Tokyo EPC	1,100	BWR	Jul 1994
Hamaoka 4	Chubu EPC	1,137	BWR	Jul 1994
Onagawa 2	Tohoku EPC	825	BWR	Jul 1995
Maki 1	Tohoku EPC	825	BWR	Sep 1996
Total gross capacity		7,887		
Plans Submitted for Approval				
Kashiwazaki-Kariwa 6	TEPCO EPC	1,355	BWR	1996
Kashiwazaki-Kariwa 7	TEPCO EPC	1,355	BWR	1998
Higashi-Dori 1	Tohoku EPC	1,100	BWR	1997
Namie-Odaka	Tohoku EPC	825	BWR	1998
Ashihama 1	Chubu EPC	1,100	PWR	1996
Ashihama 2	Chubu EPC	1,100	PWR	1997
Toyokita 1	Chugoku EPC	1,100	BWR	1997
Toyokita 2	Chugoku EPC	1,100	BWR	1999
Ohma	EPDC[4]	606	ATR	1998
Total gross capacity		9,641		

[1] Approved for planning but without authorization to start construction at this time. Following completion of public hearings, plans are submitted for the approval of the Electric Power Development Coordination Council (EPDCC).

[2] Expected Commercial Operation Date

[3] Electric Power Company

[4] Electric Power Development Company

© NUEXCO 1987

earlier approved plans for construction of Tohoku's Onagawa Unit 2 (825-MWe BWR), beginning in February 1989, scheduling for commercial operation in 1995.

Chubu Electric Power Company has proposed to the EPDCC to start construction on Ashihama Units 1 and 2 (1,100 MWe PWRs) in March 1989. These units would be scheduled for commercial service in 1996 and 1997 respectively. Chugoku Electric Power Company also proposed construction of two plants, Toyokita Units 1 and 2 (1,100-MWe BWRs), to begin in March 1989, with completion in late 1997 and late 1999. The Electric Power Development Company (EPDC) proposed a December 1988 start for construction of its Ohma unit, a demonstration 606-MWe Advanced Thermal Reactor (ATR), with completion scheduled for 1998.

Assuming the units are started as proposed, 9,640 MWe of nuclear power capacity will have been placed under construction within the next two years, by the end of Japan's 1988 fiscal year. Such a construction program would increase Japan's share of nuclear electricity generation from 27 percent in 1986 to about 37 percent by 1996.

* * *

Annual negotiations held in April between several Japanese utilities, including Tokyo Electric Power Co. (TEPCO), and Namibia's Rossing Uranium Limited have resulted in a contract price of slightly less than US $31.00 per pound U_3O_8. This represents a price reduction of about $1.00 per pound U_3O_8 from the price paid for the previous year's deliveries. Rio Tinto Zinc (RTZ) is the project's operator and largest shareholder. The low uranium spot prices prevalent during 1986 and early 1987, as well as generally low petroleum prices, have influenced the negotiations, enabling the Japanese utilities to further decrease the price paid under their long-term contracts.

SOUTH AFRICA

First-quarter uranium output from Chamber of Mines producers totaled 2,714,000 pounds U_3O_8, a decline of 2.4 percent from the fourth-quarter of 1986 (Table 3). Decreased output from Buffelsfontein (a 10-percent drop), Harmony (a 12-percent drop) and Randfontein (a 12-percent drop) chiefly accounted for the overall decline. Driefontein Consolidated, Hartebeestfontein and Western Areas also posted smaller declines. Output from the other producers remained approximately constant or increased slightly. Nuexco expects South Africa to produce about 11.4 million pounds U_3O_8 this year.

Table 3

REPUBLIC OF SOUTH AFRICA
RECENT URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	Fourth Quarter 1986	Total 1986	First Quarter 1987	Percent Change[2]
Buffelsfontein	302	1,316	271	−10.3
Driefontein Consolidated	43	180	41	− 4.7
ERGO[3]	86	343	88	+ 2.3
Harmony	116	728	102	−12.1
Hartebeestfontein	257	1,025	242	− 5.8
JMS[4]	266	1,168	275	+ 3.4
Randfontein	356	1,324	314	−11.8
Stilfontein (Chemwes)	226	638	228	+ 0.9
Vaal Reefs	997	4,255	1,025	+ 2.8
Western Areas	133	585	127	− 4.5
TOTAL[5]	2,782	11,562	2,714	− 2.4

[1] Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.

[2] Change in percent from the fourth quarter of 1986.

[3] ERGO = East Rand Gold and Uranium Company Ltd.

[4] JMS = Free State Joint Metallurgical Scheme (Freegold)

[5] Columns may not add due to rounding.

© NUEXCO 1987

BY-PRODUCT AND CO-PRODUCT URANIUM RESOURCES AND PRODUCTION

Introduction

Uranium occurs as a minor constituent in a number of minerals or mineral groups, only a few of which are important as uranium resources. Uranium produced under circumstances secondary to the production of another mineral is considered a *by-product*. Where uranium and another mineral are of relatively equal economic importance, they are termed *co-products*. Although the potential quantity of by-product uranium available worldwide is quite large, the rate and timing of production of the primary mineral controls the production rate of uranium. In most cases, the primary mineral's economic viability must support the project, while the economics of uranium production merely may offer added incentive to initiate the project.

South Africa provides perhaps the best example of uranium by-product production and economics. About 98 percent of known uranium resources in South Africa occur in association with gold in quartz-pebble conglomerates of the Witwatersrand district. During the first 65 years of mining activity uranium contained in the mined ores was sent directly to the tailings dams. By the early 1950s, recovery as a by-product of gold production had established an important uranium source. More recently, uranium recovered from the reprocessing of older tailings has added to overall production.

The numerous marine phosphate deposits scattered throughout the world, and the massive sulfide deposit at Olympic Dam, in Australia, provide other large sources of by-product and co-product uranium. Several producers in the USA and other countries extract uranium from phosphates, and a number of other countries have established pilot recovery projects in recent years. Commercial operations are scheduled to begin by late 1988 at the Olympic Dam deposit in Australia; uranium will be produced as a co-product with copper and gold. On a smaller scale, some producers are recovering uranium from mine waters in certain underground mines in the Ambrosia Lake district of New Mexico. Insofar as mine water recovery of uranium uses only the natural formation water, with no chemicals added to enhance leaching, the uranium is considered a by-product of conventional mining and recovery practices.

There also are several less important sources of by-product uranium which have been exploited in the past and which may or may not be sources of future production. These include beryllium ores in Utah, copper ores in Arizona and Utah, as well as in India, the USSR and South Africa, lignites in North and South Dakota, and rare earth recovery projects. Finally, considerable research has been undertaken to recover by-product uranium from marine black shales and from seawater. However, recovery costs have thus far greatly exceeded what would be necessary to establish economic viability. Limited research continues in both areas, but mainly in processes aimed at extracting uranium from seawater.

Overall, by-product uranium is a significant part of the worldwide uranium resource base. In the USA, for example, since 1982, conventional production has declined by almost 60 percent, output from solution mining has dropped by half, while by-product uranium production has increased slightly, from 3.2 million pounds U_3O_8 to 3.6 million pounds. Thus, by-product output has increased its share of US production from 12 percent in 1982 to 26 percent in 1986, after peaking at 32 percent in 1985.

Quartz-Pebble Conglomerates

Uranium found in conjunction with gold in the Witwatersrand complex of South Africa constitutes one of the world's largest commercially viable by-product uranium resources. South Africa's Reasonably Assured Resources (RAR) associated with gold mineralization and based on an estimated production cost of less than US$30 per pound U_3O_8 are estimated at over 560 million pounds U_3O_8 (256,000 tonnes); an additional 57 million pounds (26,000 tonnes) are contained in mill tailings, for a total of over 620 million pounds (282,000 tonnes). Estimated Additional Resources (EAR) in the same cost-recovery category would increase the total by another 216 million pounds U_3O_8 (98,000 tonnes).*

Uranium production began in 1952 at some operating gold mines in the Witwatersrand district. Annual output gradually increased, reaching a high of 16.1 million pounds U_3O_8 (7,300 tonnes) in 1980 when 21 mines supplied gold-uranium ore to 19 recovery facilities. Production declined to about 5,550 tonnes in 1986, the lowest level since 1978. Total production from uranium-bearing gold ores for the 1952-1986 period was approximately 300 million pounds (137,000 tonnes) U_3O_8.

The gold-uranium mineralization is confined to a number of reefs (conglomeritic beds) over a vertical thickness of about 4,000 meters and a fairly consistent lateral extent of 100-plus kilometers. Reserve estimates indicate that approximately 100 million tonnes of gold ore contain concentrations of uranium ranging from 0.20 to 2.00 pounds U_3O_8 per

---

* Source: *Uranium: Resources, Production and Demand*, OECD Nuclear Energy Agency/IAEA, 1986.

© NUEXCO 1987

tonne, almost all of which is found in the northern and western parts of the basin. Uraninite is the only uranium mineral identified in the reefs.

The ore minerals occur in an irregular sedimentary sequence of conglomerates and siltstones deposited in coalescing fluvial fans along the fault margins of the basin. The minerals occur as fine detrital particles in the conglomerates, with pyrite as an important accessory mineral (all minerals are syngenetic in origin). Ore concentration is a function of specific gravity plus depositional environment; ordinarily, higher gold content means lower uranium content, and vice versa.

The exploitation of a gold-uranium deposit is determined almost exclusively by the economics of gold production and only minimally by the economics of uranium. Historically, as gold prices have risen, producers have lowered their cutoff grades for mined ore. Mining a lower cutoff grade decreases the average grade of gold in the ore that is processed, but total recovered gold increases because of an increase in throughput at the recovery facility. Uranium occurs in association with the gold, so uranium output can, but does not necessarily, respond in the same way to an increase in *gold* prices.

Operators of uranium processing facilities may or may not decide to produce more uranium as a result of increased gold throughput at the gold recovery plant. If uranium prices are not high enough, they may choose to stockpile the uranium as tailings, to be processed at a later date. The price of uranium usually has little influence on this type of mining, although when uranium prices were above US $35 per pound U_3O_8, a few mines were developed mainly for uranium production, with gold being a by-product or co-product at those operations.

The basic mineral recovery process begins with coarse-grinding and gravity concentration of minerals. The heavy concentrate is then finely ground and subjected to an acid-leach/cyanidation for uranium and gold separation. The pregnant solution from both streams is clarified and sent to the ion exchange circuit. The resulting concentrate then travels to the mixer-settler (solvent extraction) circuit. Precipitation takes place when ammonium sulfate is added to the uranium-rich solution to produce an ammonium diuranate slurry (ADU) which is then calcined and packaged as U_3O_8. The tails stream is subjected to further leaching and cyanidation for final uranium and gold extraction, and to floation for pyrite extraction.

Uranium, gold and pyrite contained in the tailings at each gold recovery plant throughout the Witwatersrand Basin represent important secondary mineral resources. Although gold is the primary mineral recovered, uranium (averaging about 0.10 percent U_3O_8 per tonne) and pyrite both are potentially significant to project economics. Secondary recovery of pyrite is particularly important because originally most of the gold and part of the uranium is contained in pyrite particles. Sulfuric acid produced from the pyrite also may later be used in the uranium recovery process at conventional recovery plants.

Tailings recovery usually involves hydraulic sluicing. The sluiced material is introduced into the grinding circuit for fine-grinding and from that point the recovery process closely follows that of newly mined ore. Uranium was first produced from processed tailings in early 1978 by the East Rand Gold & Uranium Co. Ltd. (ERGO). Production from tailings at ERGO has since averaged about 400,000 pounds U_3O_8 annually.

Uranium from Phosphates

Estimates of worldwide marine phosphate resources show approximately 129,000 million tonnes, 80 percent of which are found in the USA, Morocco and the USSR. All deposits contain uranium as a trace element in amounts varying from approximately 50 to 200 parts per million (ppm). In addition, phosphate rock often contains up to three percent fluorine and traces of vanadium, thorium and rare earths, all of which are nonrecoverable using current technology.

The original depositional sequence of a primary phosphate deposit typically results in very low phosphate (P_2O_5) and uranium contents. High-grade (commercial grade) deposits are formed by weathering and reworking of the primary deposit in a marine environment. Certain environments may increase the phosphate content of the rock to more than 30 percent, but as a rule, the average is somewhat less. The Bone Valley Formation in Florida contains 10 to 15 percent phosphate; deposits in Idaho, Utah and Wyoming may contain from 18 to 24 percent. Mined rock undergoes a treatment process to increase phosphate content to over 30 percent (the minimum requirement for commercial fertilizer).

World production of marine phosphorite totaled 120 million tonnes P_2O_5 in 1986. In the USA, an estimated 31 million tonnes was produced in the Florida district, and production in the western USA was approximately another ten million tonnes. All phosphorite rock potentially can yield by-product uranium (for example, about 0.8 pounds U_3O_8 per tonne of Florida phosphoric acid processed), and US producers recovered about 3.6 million pounds U_3O_8 from Florida rock in 1986.

The most important consideration for US producers of U_3O_8 as a by-product of phosphoric acid is the uranium content of the source rock. Each phosphate uranium producer

© NUEXCO 1987

in the USA, past and present, has had mines in the central and southern Florida district, the area having the greatest economic potential both for phosphoric acid and uranium production. The deposits that occur in the Bone Valley Formation have the highest grade phosphate and uranium content in the region, averaging approximately 0.015 percent U_3O_8 (equivalent to 0.3 pounds U_3O_8 per short ton of phosphate rock), compared to 0.008 percent for the remainder of the region.

Currently, uranium cannot be extracted directly from phosphate rock; uranium recovery takes place during phosphoric acid production. The production of uranium from phosphates requires "wet process" technology, which uses sulfuric acid to dissolve the phosphate rock (acidulation). The process creates phosphoric acid, with gypsum precipitated as a waste-product, which is filtered out as tailings. Depending on redox potential, from 85 to 95 percent of the natural uranium is codissolved with the phosphorite and stays with the phosphoric acid. Recovery of uranium from the phosphoric acid stream usually exceeds 90 percent. Uranium cannot be recovered from phosphoric acid made from elemental phosphorus, the process used on phosphate rock at production centers in the western USA.

The technology for extracting uranium from phosphoric acid originally was developed by the US Atomic Energy Commission (AEC) in 1947. Four US phosphoric acid producers participated in the AEC's research and development project, which focused on the Pyro solvent extraction process, called the OPPA process (after the *octylpyro-phosphoric acid* extractant). The process consisted of four basic steps following acidulation:

1. Reduction of uranium contained in phosphoric acid by the addition of iron;
2. Solvent extraction utilizing octylpyro-phosphoric acid diluted with kerosene;
3. Clarification of the pregnant solution, and;
4. Stripping, precipitation, purification and drying of the uranium concentrate.

The project produced slightly more than one million pounds U_3O_8 from 1954 to 1962, when it was terminated because production costs were no longer competitive with new conventional uranium mining projects in New Mexico and Wyoming.

The Oak Ridge National Laboratory (ORNL) also operated a pilot recovery program throughout the 1960s and into the mid-1970s, developing two additional recovery processes based on improved solvents and new technology. The DEPA-TOPO process (after *di-2-ethyl-hexyl phosphoric acid* [D_2EHPA] and *tri-octyl-phosphine oxide* [TOPO] extractants) was developed in the late 1960s, and the OPAP process by the early-1970s. The DEPA-TOPO process has proven to be the most commercially efficient recovery method. This two-stage process uses a solvent mixture to extract, concentrate and purify uranium. The OPAP process uses the solvent octylphenyl acid phosphate to concentrate the uranium, which is extracted and purified with DEPA-TOPO solvent during a second stage.

Treatment of the acid is one of the most important steps in using the basic DEPA-TOPO recovery process. Florida phosphate rock contains about one percent organic material, much of which is soluble and cannot be removed by filtration. Its presence creates "black" acid, an undesirable product that tends to coagulate on contact with DEPA-TOPO extractant, forming a "crud" which interferes with uranium extraction. Organic-free acid is referred to as "green" acid from which uranium is readily recovered.

Proprietary technology has been developed by several organizations to remove organics from the acid stream. Oak Ridge National Laboratory developed the use of activated carbon to remove the organic material, reportedly improving solvent extraction, reducing scaling in pipes and tanks, and allowing the use of chemical rather than thermal regeneration. Current operators may use various methods, including activated carbon, to remove the organic humates, but the desired end result in every case is clean, "green" acid.

Primary uranium extraction begins with oxidation of the uranium, followed by the addition of DEPA-TOPO solvent and an organic solution which causes the uranium to transfer to the solvent. The uranium-bearing solution is separated from the phosphoric acid, and the uranium-free acid (raffinite) returns to the acid plant for final processing into fertilizer and related products. By bringing the solvent into contact with a small amount of phosphoric acid treated with metallic iron, the uranium is stripped from the loaded solvent and reduced to the tetravalent state.

Secondary extraction includes another oxidation stage to recreate hexavalent uranium. The oxidized uranium in solution, which contains a high concentration of uranium from the primary circuit, is reloaded onto DEPA-TOPO solvent. The loaded solvent is cleaned with a water rinse and then stripped by adding ammonium carbonate to form a precipitate of ammonium uranyl tricarbonate (AUT). The AUT is then filtered, leaving uranium concentrate (yellowcake) ready for drying and packaging. Uranium recovery normally varies from 0.5 to 1.3 pounds U_3O_8 per short ton of phosphoric acid processed, depending on the phosphorite rock's uranium content and the efficiency of the recovery process.

Many steps in the DEPA-TOPO recovery process have been modified and are now considered proprietary by the different participating companies. The above procedures are

© NUEXCO 1987

basic to recovery technology and should not be considered as a complete or final process outline. Worldwide, there were eight DEPA-TOPO plants operating in 1981; six in the USA, one in Belgium and one in Taiwan. By the end of 1986, US operating production facilities had declined to four, with one new producer in Canada. (Two companies had operated OPAP plants, both of which were closed by 1981.) Table 4 lists the companies, rated annual capacity and location of plants extracting uranium from phosphates.

Multi-Mineral Ores

At present, by-product recovery of uranium from multi-mineral ores is limited to operations in South Africa, the USA and the USSR. In South Africa, multi-mineral by-product uranium is recovered from copper sulfide reserves at the Palabora mine. In the USA the many waste dumps associated with porphyry copper mines also could provide a resource base. Historically, the USSR has produced a great deal of uranium from low-grade uranium ores associated with other minerals. Several other countries including India and Argentina recover uranium during processing of copper ores; although total recovery has been small, the potential resource base is important to those countries.

Australia has the greatest potential for recovery of co-product uranium from multi-mineral ores. Estimates made of the Olympic Dam copper/uranium/gold deposit indicate over 2 billion tonnes of ore, with a uranium content of 0.06 percent U_3O_8, or approximately 2.6 billon pounds U_3O_8. Commercial development of the deposit has begun and uranium recovery is integral to the project's economics.

Australia — The copper/uranium/gold deposit located in South Australia is perhaps the largest sulfide mineral accumulation ever discovered, covering an area of 20 square kilometers. Estimated reserves total over two billion tonnes

Table 4

PLANTS FOR BY-PRODUCT RECOVERY OF URANIUM FROM PHOSPHATES

Company	Location	Process Type	Annual Capacity (thousand pounds U_3O_8)	Start/Close	Production (thousand pounds U_3O_8)		
					1984	1985	1986
Intl. Min. & Chem. (IMC)	New Wales, FL	DEPA-TOPO	1,400	1980/OP[2]	900	1,150	1,100
IMC/C.F. Industries	Plant City, FL	DEPA-TOPO	700	1980/OP	600	750	700
Freeport Uranium Co.	Uncle Sam, LA	DEPA-TOPO	800	1978/OP	797	670	700
Freeport Uranium Co.	Donaldsonville, LA	DEPA-TOPO	450	1981/OP	432	426	400
Earth Sciences/UG[2]	Calgary, Alberta	DEPA-TOPO	120	1983/OP[4]	104	118	90
Chemie Rupel	Engis, Belgium	DEPA-TOPO	150	1980/OP[4]	120	120	120
China Phosphate	Taiwan	DEPA-TOPO	50	1981/OP[4]	—	—	—
IMC/C.F. Industries[6]	Bartow, FL	DEPA-TOPO	700	1980/85	0	132	0
UG USA	Pierce, FL	DEPA-TOPO	450	1978/81[5]	—	—	—
Uranium Recovery Corp.	Bartow, FL	OPAP	330	1976/80	—	—	—
UNC	Mulberry, FL	OPPA	100	1955/61	—	—	—
U.S. Phosphoric	Tampa, FL	OPPA	200	1955/61[7]	—	—	—
Gardinier	Tampa, FL	OPPA	450	1979/82	—	—	—

[1] OP = Plant operating as of Jan. 1, 1987.

[2] Earth Sciences Inc/UG-USA/Western Coop. Fertilizers Ltd. joint venture, processing Florida phosphate rock.

[3] Production from imported phosphate rock.

[4] Originally Wyoming Mineral Corp./Farmland Industries. Sold to Uranium Extraction Florida, Inc. (UEF) in 1985. Currently owned by UG (Urangesellschaft) USA. Plant undergoing renovation with start-up (DEPA-TOPO process) in near future.

[5] Uranium recovery facility on stand-by.

[6] Sold to Gardinier, plant renovated and re-started in 1979.

© NUEXCO 1987

of ore, averaging 1.6 percent copper, 0.06 percent uranium, and 0.6 grams/tonne of gold. The deposit is owned by the joint venture of Roxby Mining Corporation Pty. Ltd. (a wholly-owned subsidiary of Western Mining Corp.) with 51 percent, and the BP Group (BP Australia Ltd., and BP Petroleum Development Ltd., 36.5 and 12.5 percent respectively) with 49 percent.

Delineation drilling has revealed an internal high-grade ore block containing approximately 450 million tonnes of ore with average grades of 2.5 percent copper, 0.08 percent uranium, 0.6 grams gold and 6.0 grams silver per tonne. The uranium contained in that high-grade ore block is estimated at over 800 million pounds U_3O_8 (360,000 tonnes). During 1980/81 the operators sank an exploration shaft to a depth of 500 meters in the high-grade ore block in order to carry out a detailed underground evaluation program.

The partners made a decision in December 1985 to proceed with commercial development of the high-grade block, based on recovery of the three principal minerals. Construction began in March 1986 in preparation for initial production by mid-1988. The first development phase will allow the operators to produce approximately 30,000 tonnes of refined copper, 5.2 million pounds U_3O_8, and 90,000 ounces of gold. To accomplish this production goal, the mining rate will be increased to about one million tonnes of copper ore, 0.5 million tonnes of gold ore, and 0.5 million tonnes waste per year. Eventually, annual copper production could total about 150,000 tonnes, and U_3O_8 will total about 8.8 million pounds.

South Africa — The presence of uranium in association with copper sulfide minerals in the Palabora deposit of South Africa was first noted in 1952. Uranium was first recovered from the ore in 1971, and by the end of 1986, approximately 7.3 million pounds of U_3O_8 (3,300 tonnes) had been produced as a by-product. Output at Palabora averaged 480,000 pounds U_3O_8 during the years 1981 to 1985, with a peak of nearly 570,000 pounds (260 tonnes) in 1982. Recoverable resources contained in the remaining mineable copper ore are estimated at approximately 2.4 million pounds U_3O_8 (1,100 tonnes) at an average grade of 0.0035 percent uranium.

USA — In 1965, the US Bureau of Mines noted the presence of uranium in acid solutions used to leach the oxidized ores and waste dumps at copper deposits throughout the western USA. By 1967, Kennecott Mining Company and the Bureau of Mines had constructed an 800 gpm pilot project to perfect an ion exchange uranium recovery process at the Bingham Canyon mine in Utah.

Kennecott contracted with Wyoming Mineral Corp., a subsidiary of Westinghouse Electric Corp., to establish a commercially viable recovery process in 1974. Wyoming Mineral designed and constructed a 6,700 gpm plant to treat leach solutions migrating through waste dumps and feeding the copper cementation plant. The uranium recovery plant, which collected the solution downstream of the copper plant, began operating in 1977 at a rated annual capacity of 140,000 pounds U_3O_8. The plant operated at capacity in 1982, but by 1985 production had declined to only about 60,000 pounds. Wyoming Mineral placed the operation on standby in 1985, and later sold it to Energy Fuels Nuclear in 1986. Energy Fuels reopened the plant in February 1987 and will be producing at a rate of approximately 10,500 pounds U_3O_8 per month.

Anamax, a 50/50 joint venture of Amax, Inc. and the Anaconda Company, also produced by-product uranium at the Twin Buttes porphyry copper open-pit mine at Sahuarita, Arizona. The deposit's upper mineralization consisted of a copper oxide halo containing uranium measured at about 10 to 15 ppm, just enough to contaminate the copper mined from the oxide zone. To recover the uranium, the ore was treated by acid leaching, with the disolved uranium and copper being separated in the copper solvent extraction circuit. The uranium recovery plant's rated capacity was about 120,000 pounds U_3O_8 annually. Uranium production began in 1980, growing to over 200,000 pounds in 1981 and 1982. Output had declined to about 100,000 pounds by 1985 as oxide ore reserves were depleted. The uranium plant was shut down in November 1985.

USSR — By-product uranium has been produced from mines in almost every metal mining district of the country, stretching from the Siberian and Aldan shield regions in the northeast to the southern limits of the Chatkal/Ferghana district in Uzbekistan. In each district, uranium may occur in association with one or more minerals including copper, vanadium, molybdenum and galena. Lignite also provides some uranium by-product recovery in three different areas in the vicinity of the Osh lignite belt. In addition, uranium is recovered from iron ore in the Terny/Zholtye Vody mines located in the heart of the Krivoi Rog iron district in Dnepropetrovsk Province. Although information about the quantity of by-product uranium production in the USSR is not publicly available, such resources will continue to be an important source of uranium in the USSR.

Uranium from Mine Water

A few underground mines in the Ambrosia Lake district of the Grants mineral belt in New Mexico currently recover uranium by processing groundwater pumped from the mines.

Quivira Mining Company (a subsidiary of Kerr-McGee Corp.) produced 146,000 pounds U_3O_8 from mine water at its Ambrosia Lake operations in 1986. Homestake Mining Company produces about 250,000 pounds U_3O_8 annually from mine water recovery.

Water containing from 4 to 7 ppm uranium flows naturally into the mine workings, where it is pumped to the surface and passed through an ion exchange circuit to remove the uranium. The water is then returned to the mine site and reinjected through drill holes into mined-out stopes, where it makes contact with broken ore, achieving concentrations of up to 15-30 ppm uranium. Under carefully controlled conditions, the uranium content may increase to 40-60 ppm, but this usually does not occur on a sustained basis.

The cycle of pumping and stripping continues repeatedly as the pregnant solution from the ion exchange circuit is further processed by conventional methods to produce uranium oxide. Several million pounds of uranium have been produced by following this method over the past few years. Uranium also is recovered from mine water in underground mines in France and from the Ranger open-pit mine in Australia. The water is not recycled after uranium extraction.

Although the potential for such production exists in all underground uranium mines where formation water commonly occurs, it represents a limited resource base whose size is difficult to estimate. However, it is possible that 10 to 15 percent of reserves associated with a wet underground uranium mining operation could eventually be recovered by processing mine waters.

Minor and Potential Resources

Small-scale by-product uranium production has been achieved from several different sources in the past, such as lignites, beryllium and rare earths. Other potential resources include black marine shales, and seawater. As with most other by-product sources, the nature of the uranium occurrence and economics of the by-product recovery processes, as well as the market for uranium, have had the greatest influence on production.

Lignite — The uranium content of most lignites and coals is extremely low, and potential recovery from ash is uneconomical. A study by the US Geological Survey failed to identify any lignite or coal in the USA that could be considered an important source of uranium. However, during the 1950s and 1960s a few isolated lignite sources were mined for unusually high uranium content (from 0.05 percent to 1.00 percent U_3O_8) in North and South Dakota. The uranium (and molybdenum) was concentrated in the lower portion of the lignite seam, indicating probable redistribution of uranium through weathering and alteration.

To recover the uranium, the operators mined and hauled the mineralized portion of the lignite seam to a plant for burning and ash collection. Uranium retained in the ash could be concentrated three to six times, after which the ash was transported to a conventional mill for mixing and processing with regular mill feed. Lignites in North and South Dakota produced totals of 595,000 and 744,000 pounds respectively. It is extremely unlikely that future mining of these deposits for uranium will occur due to economic and environmental considerations. Other lignite occurrences are not known to be mined sources of by-product uranium, except those already mentioned in the USSR. Uraniferous lignites occur in South Africa but have not been mined to date.

Beryllium — Several large deposits of uraniferous beryllium were discovered in the Topaz-Spor Mountain area of western Utah in 1959. The mineralization is disseminated in water-laid tuffs in which the average uranium content is approximately 0.015 percent U_3O_8. Brush Wellman Inc., owner of the deposits, began mine development and mill construction in 1968; beryllium production started in 1969 at a rate of 350 tons of ore per day. The mine and mill presently is the only beryllium extraction project in the western world.

The principal ore mineral in this deposit is bertrandite, a hydrous beryllium silicate. Several million tons of bertrandite ore have been identified in as many as eight separate orebodies, with an average grade of 0.60 percent to 0.70 percent BeO. Both the beryllium and associated uranium ore minerals are submicroscopic and are found concentrated in fluorite nodules. Uranium occurs only in the upper half of the beryllium-bearing tuffs, and extends upward into the overlying altered rhyolite flow rock.

Ore processing begins with fine-grinding and sulfuric acid leaching under high temperatures. Solids are removed from the pregnant solution in the counter-current decantation (CCD) circuit, and the solution then travels through the solvant extraction circuit which separates beryllium, uranium, iron, aluminum and fluoride from other elements. Beryllium is dissolved in a special organic solution added to the mixture, which is then stripped of beryllium and filtered. The filtrate contains the uranium, which can be recovered by conventional precipitation methods, or can be sent directly to solar ponds for storage and subsequent recovery. Uranium extraction began in 1981, and through 1982 the operators produced about 35,000 pounds of U_3O_8. The uranium circuit has been shut down since early 1983.

Rare Earths — Uranium is a potential by-product in the production of rare earth minerals. The ores often originate from diverse sources and contain a wide variety of minerals belonging primarily to the columbate and tantalate groups.

© NUEXCO 1987

many of which contain small quantities of uranium. Uranium extraction may even be required to produce acceptable purity in the primary products columbium and tantalum, and to produce clean tailings. The quantities processed are usually small because requirements for rare earths are limited by competition and specialized demand. By-product uranium production from rare earth recovery projects in the USA totaled less than 30,000 pounds in 1986. Producers in India have been actively engaged in research to recover uranium from several rare earths deposits, but production in other countries, if any, is unknown.

Black Shales — Uranium has not been produced from black shales on a commercial basis. Considerable research and development has been committed to uranium-bearing shales, but economically competitive recovery technology does not yet exist. Worldwide, black shales are uraniferous; however, only the Ranstad deposit in Sweden and the Chattanooga Shale deposit in the east-central USA have been evaluated in detail. Both deposits contain many millions of tonnes of uranium-bearing shale that have some potential for recovery of uranium and associated minerals.

Uranium concentration averages 300 ppm in an upper layer of the Ranstad Shale Formation of Cambrian-Silurian age. Estimates place the deposit's mineable U_3O_8 potential at approximately 660 million pounds (300,000 tonnes). A pilot mine and processing plant with an annual capacity of over 250,000 pounds U_3O_8 were built in the early 1960s and operated until 1969. It has since operated as a research facility, investigating recovery of uranium and several other potentially valuable constituents, including kerogen and pyrite. The uranium extraction process includes acid leach, ion exchange and solvent extraction, stripping by the addition of sodium carbonate, and precipitation with sodium hydroxide to produce sodium uranate. Operation of a commercial-scale facility at Ranstad would require a sharp increase in uranium prices and demand.

The Chattanooga Shale is a marine deposit of Devonian age that occupies all of central Tennessee, extending northward into Kentucky and southward into Alabama. In 1944, the US Geological Survey first evaluated the Chattanooga Shale as a low-grade uranium resource. Results indicated a potential uranium resource of about 4.5 million tonnes U_3O_8. The Atomic Energy Commission (AEC) initiated a second study in 1947, covering an area of approximately 35,000 square miles. The US Department of Energy (DOE) also directed a further evaluation of the shale, covering a select area of about 3,000 square miles along the Eastern Highland Rim in Dekalb County, Tennessee.

The DOE study included experimental laboratory procedures to recover as many minerals as possible, including oil, and to establish the technical and economic feasibility of commercial production on a scale of 33,000 tonnes per day produced by underground mining methods. The uranium content of the Chattanooga Shale varies from 55 to 65 ppm. In addition, it contains important concentrations of vanadium, cobalt, nickel, molybdenum, thorium, and the oil constituent kerogen. By 1978, when the study was completed, available technology could recover uranium, syncrude, ammonia and sulfur from the shale, but not the other minerals. The project proved uneconomic at likely recovery prices for the primary minerals contained in the shale.

The study ended with recommendations for a five year experimental mining and extraction program, leading to a full-scale commercial project within 20 years. Experimental development of the Chattanooga Shale is stalled by limited demand for the deposit's recoverable minerals, and serious environmental problems attending such a high-volume mining and processing operation that would be located in a relatively highly populated and developed area.

Seawater — Seawater contains an average uranium content of 3 to 4 ppb (parts per billion). Studies investigating possible recovery of uranium from seawater began in England during the early 1960s, but initially showed recovery costs exceeding $1,200 per pound U_3O_8. Research and development has continued in England and Japan, and more recently, recovery costs of approximately $300 per pound were foreseen. The US DOE sponsored a feasibility study conducted by Exxon and Oregon State University in 1978 which concluded that uranium extraction from seawater was not economically feasible in the USA. Currently, the Metal Mining Agency of Japan is involved in a pilot plant study at Nio, on Seto Island to extract uranium from seawater. The study is scheduled to be concluded in late 1987.

The basic technology for uranium recovery from seawater includes exposure of seawater to a mix of hydrous titanium oxide and other select oxihydrates. Uranium is adsorbed by the mix and in turn is eluted with an ammonium carbonate, or sodium bicarbonate and sodium carbonate solutions. Precipitation can take place by heating the uranium-rich ammonium solution or by the addition of sodium hydroxide to the sodium solutions. Recovery of uranium from seawater currently does not appear practical without a drastic improvement in extraction technology or tremendous increases in uranium prices, or both.

Conclusion

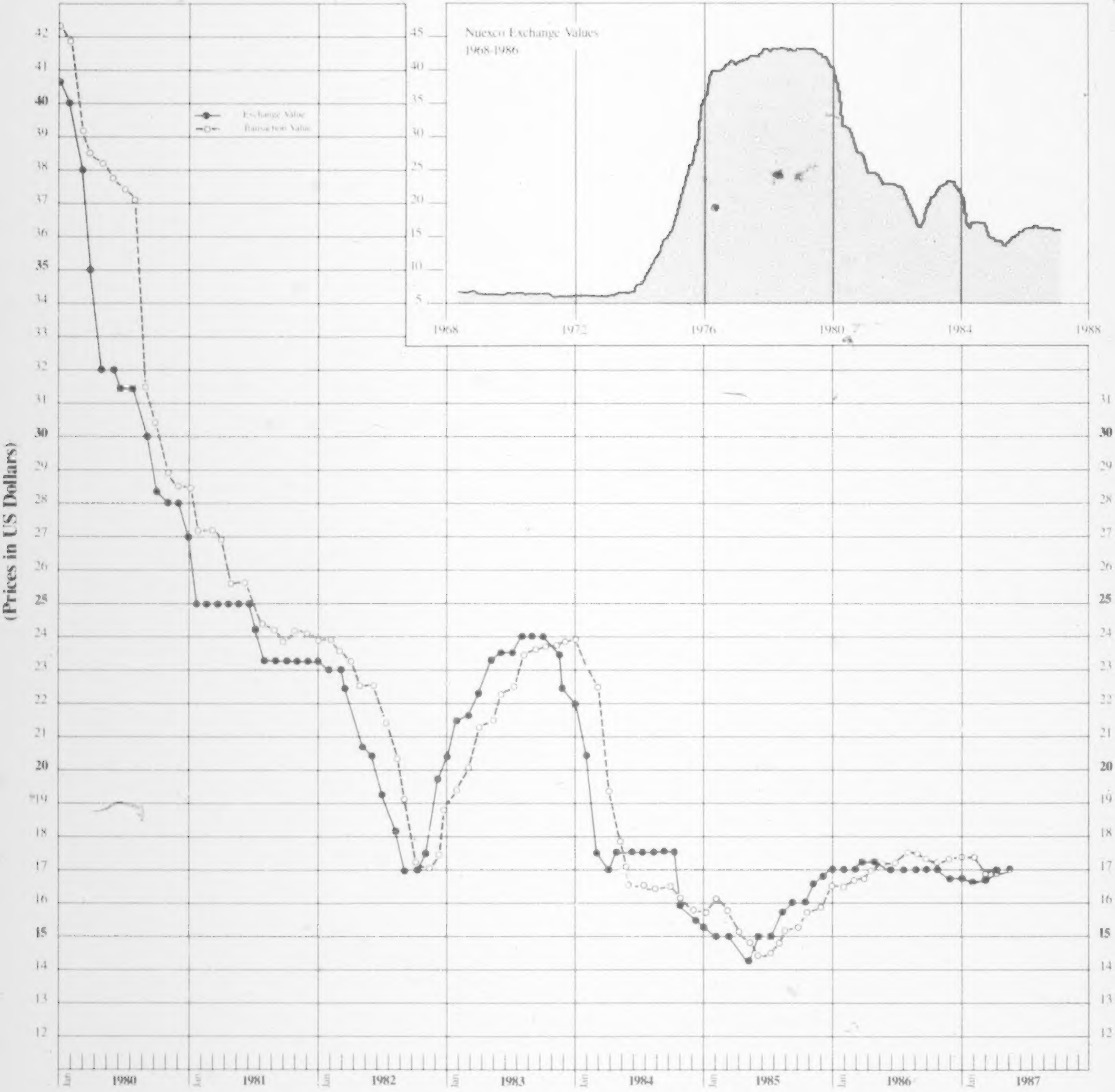
Suppliers of uranium from major by-product producing operations will likely continue to produce at approximately current levels, and production from Olympic Dam represents the only significant increase expected from co-product sources. The combined production of by-product and co-product uranium from all sources will continue to be an integral part of total world production.

Based on uranium price forecasts and the lack of economically viable recovery technology, Nuexco does not expect renewed production from minor sources or new production from potential sources in the near future, perhaps not within the next 15-20 years. Commercial recovery technology does not exist for the large low-grade resources (black shales) and recent research is mainly directed toward one area — uranium from seawater. Only a drastic change in overall industry supply and demand could create the impetus for commercial-scale production from either source.

© NUEXCO 1987

NUEXCO

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	**17.00**								

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	**17.00**								

© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	**1.80**								

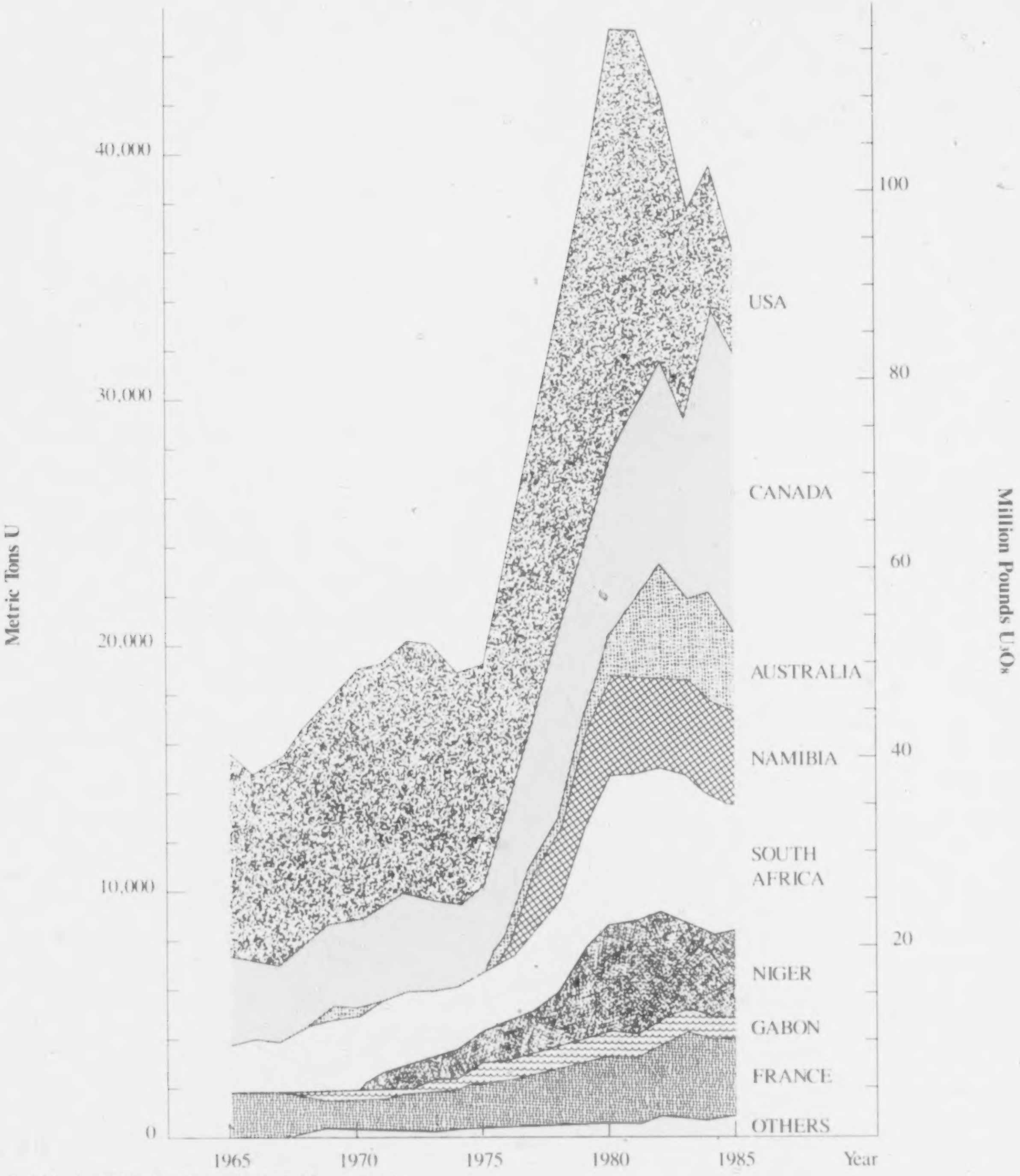
HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	**48.00**								

©NUEXCO 1987

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA – World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium (\$/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

© NUEXCO 1987

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

© NUEXCO 1987

GOVERNMENT STATISTICS

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1975 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]	133.6	100.0	—
FY86 Avg.[7]	—	105.0	—
Jan 1986		109.6	210.0
Feb 1986		108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986		94.3	210.5
May 1986		93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986		98.1	215.3
Aug 1986		98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986		106.2	215.4
Nov 1986		105.2	215.6
Dec 1986		105.5	215.6
Jan 1987	—	106.4	215.9R
Feb 1987	—	—	216.5

P = Preliminary   R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5] Annual averages prior to 1979 reflect index base no longer in use.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

[7] Annual averages are for financial year ending June 30.

© NUEXCO 1987

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1R	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79R	16.19	13.06	11.57	12.99
Jan 1987	120.0R	19.52P	16.79P	16.11P	12.90P	12.54P	12.89P
Feb 1987	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

© NUEXCO 1987

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.70	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754;788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	—	—
Feb	1987	—	—	251.0	237.0	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.[illegible]3	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6	298.4	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.16	12.20	9.85
Jan 1987	313.6	300.9	333.1	—	12.80R	13.10R	12.17R	9.86R
Feb 1987	315.7	302.7	334.4	—	12.79P	12.96P	12.20P	9.87P
Mar 1987	315.8	302.8	335.9	116.2	—	—	12.26P	9.86P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

© NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA James G. Munro
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA Chris I. Von Christierson
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES Harold C. Lindberg
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN Kazy Yokota
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN Edward Bee
Bee & Liang Company, Ltd.
14 Fl. Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES Ralph O. Smith
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

B6800-1A -
6/19/87

NUEXCO

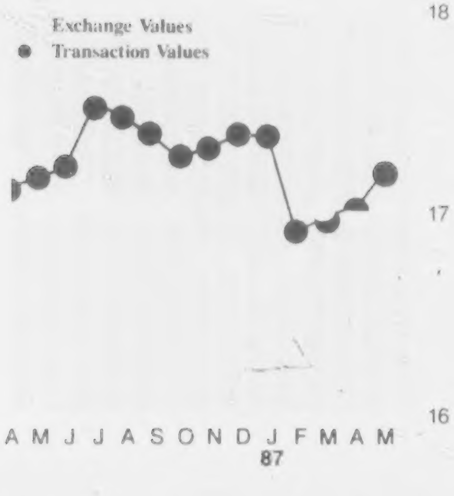
Monthly Report

June 1987 Number 226

Secondary SWU Market Forecasts 13

Results of Japanese Utilities' Annual NUFCOR Negotiations 21

Decommissioning of Nuclear Plants, Part 1 23



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900   1515 Arapahoe Street   Denver, Colorado 80202 USA
Telephone: (303) 893-4015   Telecopy: (303) 825-4821   Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

DIRECTOR OF OPERATIONS — Transaction Services	James E. Lewis
DIRECTOR OF OPERATIONS — Information Services	J. Fred Lawrence

Manager of Fuel Transactions		Earl E. Hoellen, Jr.
	Australia	George White, Jr.
	Far East	Earl E. Hoellen, Jr.
	North and South America	Earl E. Hoellen, Jr.
	Southern Africa	James E. Vaughan
	Europe	James E. Vaughan
Manager of Legal and Regulatory Affairs		Frederick J. Boyne
Manager of Property and Equity Transactions		Don A. Nichols
Manager of Information and Consulting		R. Gene Clark

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO
1987 INTERNATIONAL DIRECTORY OF NUCLEAR UTILITIES
(IDNU)

Distributed by Nuexco (formerly by Lotte Ltd.)

The Nuexco 1987 International Directory of Nuclear Utilities provides a convenient, well-organized reference system containing the following important information:

- **UTILITIES OPERATING NUCLEAR POWER STATIONS**
  - Full Names
  - Corporate Addresses
  - Telephone and Telex Numbers
- **NUCLEAR POWER STATIONS**
  - Names
  - Local Addresses
  - Telephone Numbers
  - Plant Type and Capacity
- **PERSONNEL – Names and Titles of:**
  - Corporate Executives
  - Administrative Managers
  - Technical Managers
  - Plant Site Directors and Managers
- **ALSO CROSS-INDEXED BY:**
  - Utility Name
  - Nuclear Power Station
  - Personnel Name

The International Directory of Nuclear Utilities enables you to quickly find the information you need, to contact the persons you need. Organized alphabetically by country, the Directory is an indispensable tool for finding information about the world's nuclear utility companies.

1987 EDITION: $195.00

(Airmail postage paid worldwide)

Order your copy immediately!

Please send the 1987 edition of the **INTERNATIONAL DIRECTORY OF NUCLEAR UTILITIES.**

__________ is enclosed in the form of
☐ CHECK ☐ MONEY ORDER
Credit Card Authorization for.
☐ AMERICAN EXPRESS ☐ MASTERCARD
☐ VISA

Credit Card Account Number

MasterCard Bank Number

Expiration Date

Authorized Signature

Ship to: (please PRINT) Date: __________

Name __________

Company __________

Address __________

City __________

State __________ Zip __________

For information on orders of ten or more copies to the same address please call (303) 893-4015, or write to:

NUEXCO
Three Park Central, Ste. 1045, Denver, Colorado 80202 USA
Attn: Lori Costarella
(303) 893-4015

ISBN-0-9612054-3-1

NUEXCO

NUEXCO REPORT 226 FIGURES OF THE MONTH (May 31, 1987)	This Month (Report 226)	Last Month (Report 225)	12 Months Ago (Report 214)
Exchange Value[1]	17.00	17.00	17.00
Transaction Value[1]	17.20	17.00	17.15
UF_6 Value[2]	47.75	48.00	48.25
Loan Rate[3]	3%	3%	4%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	4.1	4.5	4.2
Near-Term Uranium Demand[6]	1.4	0.6	1.0
Near-Term Supply-Demand Ratio	3.0	7.8	4.3
Recent Uranium Sales:			
Number of Transactions[7]	6	10	6
Quantity of Material[8]	5.3	4.1	1.2
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	75	77	75
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	450	455	450
3.0 w/o U_{235}	575	582	575
3.5 w/o U_{235}	702	711	702
4.0 w/o U_{235}	831	842	831

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (225)

Section	Topic	Page
Analysis and Commentary	Five-Year World Production Forecast	13
Japan	Utilities Conclude Annual Rossing Delivery Price	19
South Africa	First Quarter 1987 Production Results	20
Raw Materials	By-Product and Co-Product Uranium Resources and Production	21
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in April 1987	1
	Enriched Uranium and SWUs Pricing in April 1987	2

© NUEXCO 1987

NUEXCO

EXECUTIVE SUMMARY
REPORT 226
(All data as of May 31, 1987)

Exchange Value
\$17.00, unchanged

The **Exchange Value** is **\$17.00** per pound U_3O_8, unchanged since last month.

UF_6 Value
\$47.75, down 0.25

The **UF_6 Value** is **\$47.75** per kilogram U as UF_6, down 0.25 since last month.

Transactions

Four recent natural uranium sales are reported, involving **5.1 million** pounds equivalent U_3O_8. Three of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value. Two transactions also are reported involving low-enriched UF_6, totaling approximately 250,000 pounds equivalent U_3O_8.

Supply-Demand Ratio
decreased to 3.0:1

Active spot and near-term **uranium supply** amounts to **4.1 million** pounds U_3O_8 equivalent, down **415 thousand pounds** since last month. Active spot and near-term **uranium demand** totals **1.4 million** pounds, up **800 thousand** pounds from last month. The spot and near-term **supply-demand ratio decreased** to **3.0:1.**

Transaction Value
\$17.20, up \$0.20

The **Transaction Value** is **\$17.20** per pound U_3O_8, **up \$0.20** since last month. The calculation includes 17 transactions involving a total of 3.1 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate
unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value
\$1.80, unchanged

The **Conversion Value** is **\$1.80** per pound U as UF_6, **unchanged** since last month. Active secondary market supply for conversion services for delivery within three years totals **580** thousand pounds U as UF_6. No active demand is listed this month. No secondary market conversion transactions are reported.

SWU Value for
delivery within
one year: \$75,
down \$2.00

The **SWU Value** at .3 tails and for delivery within one year is **\$75** per SWU, down \$2.00 since last month. Two secondary market SWU transactions are reported.

* * *

Analysis and
Commentary

The secondary market for enrichment services is expected to remain relatively dormant through the early 1990s. Uncommitted SWU requirements will remain at a level of under one million SWU per year until about 1990, increasing to about four million SWU per year by 1995. After 1995, excess production capacity and uncommitted requirements could gradually increase the volume of SWU sold on the secondary market.

Basic Considerations

Decommissioning of nuclear power plants will become increasingly necessary in coming years, as many plants approach the end of their operating lives. Part One of this article examines future trends in numbers of plants to be decommissioned, alternative decommissioning strategies, and some social issues that could affect decommissioning schedules.

Japan

Annual price negotiations concluded between several Japanese utilities and South Africa's Nuclear Fuels Corporation (NUFCOR) for uranium delivered under long-term contracts, have concluded with an agreed price of US \$30.50 per pound U_3O_8, unchanged since the previous year. In other developments, Tokyo Electric Power Company (TEPCO) announce plans to begin construction of two new advanced BWRs in 1991 and 1993, respectively. General Electric Corporation of the USA will provide part of the plant equipment.

This Executive Summary may be reproduced for internal distribution

© NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

June 1987 No. 226

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 3

CURRENT MARKET DATA

Nuexco Market Values 4
Nuexco Market Values Expressed in Selected Currencies 5
Recent Transactions 7
Supply and Demand Tables 8

ANALYSIS AND COMMENTARY

The Secondary SWU Market in the 1990s 13

RECENT DEVELOPMENTS

Japan 21

BASIC CONSIDERATIONS

Decommissioning of Nuclear Plants, Part 1 23

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 32
Historical Exchange Values and Transaction Values 33
Historical Conversion Values and UF₆ Values 34
Graph of World Uranium Production 35
US Uranium Marketing Activities Statistics 36
Volume and Price of Uranium Deliveries to the European Community 37

GOVERNMENT STATISTICS

Australia 38
Canada 39
South Africa 40
United States 41

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

NUEXCO

To Our Readers

We are pleased to announce that Mr. Hans W. Vogt has accepted appointment to Nuexco's International Advisory Committee. Mr. Vogt has been involved in the nuclear power industry since the 1960s, after receiving his degree in Electrical Engineering at the Swiss Federal Institute of Technology in Zurich, and he has extensive experience both in Europe and in the USA. He was formerly director in charge of construction and plant startup of the Gösgen nuclear plant, and later served as director of the plant's nuclear fuel management and supply operations. Mr. Vogt also has been involved in evaluating bids for the Kaiseraugst nuclear plant, and very recently has accepted the position of President of EAO-Holding Company; Lumipost AG, an electrical-mechanical manufacturing company in Olten, Switzerland.

©NUEXCO 1987

NUEXCO

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of May 31, 1987)

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **4,080,000** pounds U_3O_8 equivalent, down 415 thousand pounds since last month. The corresponding figure for **active demand** is **1,375,000** pounds, up 800,000 pounds. The spot and near-term **supply-demand ratio** decreased to **3.0 to 1.**

The *Current Market Data* section of this Report lists four natural uranium concentrate sales, totaling 5.1 million pounds U_3O_8 equivalent. In addition, two transactions involving low-enriched UF_6 are reported, totaling 250,000 pounds equivalent U_3O_8. US-origin uranium is commanding a premium (relative to the Exchange Value) of $0.90 per pound U_3O_8 (down $0.60) in the form of concentrates, and $2.25 per kilogram U (down $0.75) in the form of UF_6.

The **Transaction Value** is **$17.20** per pound U_3O_8, up $0.20 since last month. The calculation extends over a 3-month period and includes 17 transactions involving 3.1 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, down $0.25 since last month. Canadian sellers have become somewhat more aggressive, after missing some recent market opportunities.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 580 thousand pounds U as UF_6. No active demand is reported this month. No secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value remained at $17.00 this month. Activity in the spot and near-term markets for U_3O_8 diminished in May, as compared to the last several months. One long-term sale to a European utility which was negotiated earlier in the year, is reported, totaling over 4.7 million pounds, and three other buyers concluded U_3O_8 spot purchases. Altogether, transactions involving more than 5.3 million pounds U_3O_8 equivalent were concluded during May. The supply-demand ratio has declined since last month, as supply decreased slightly and demand increased due to recent inquiries by US and European utilities.

The uranium market remains fragmented because of legislative, judicial and political factors; origin and physical location of material are still the prime determinants of price. The main factors are the still unresolved US Producers vs. DOE lawsuit, the US Anti-Apartheid Act of 1986, new legislation proposed in the US Congress, the Canadian upgrading policy, and various restrictions on end use due to non-proliferation concerns.

The premium (relative to the Exchange Value) for US-origin concentrates declined $0.60 to a new level of $0.90 per pound U_3O_8. Of the three spot natural uranium sales reported this month, two involved US-origin uranium and totaled less than 200 thousand pounds U_3O_8. Demand for US-origin concentrates remains weak, and some small lots of US-origin material are available at prices slightly below those offered for larger quantities. For significant quantities of US mine-origin uranium, prices asked by US producers remain higher than the sum of the Exchange Value and the premium (i.e. the incremental price commanded by US-origin material in transactions where the buyer restricts the acceptable origin to US), and higher than US-origin created through swaps or sold from traders' stocks.

Because of the uncertainty surrounding the origin issue, US utilities have substantially reduced levels of non-US-origin uranium in inventory. As a consequence, the demand for swaps into US-origin has fallen, and swap fees have dropped below the current premium for US origin. The distinction currently being made by some buyers of US-origin material between mine-origin uranium and that created through flag swaps has added downward pressure on swap fees.

Since the original decision in the US Producers vs. DOE lawsuit in June 1986, and DOE's subsequent appeal to the Tenth Circuit Court of Appeals, rumors of an imminent court decision have periodically circulated through the uranium industry. Nuexco has received, and continues to receive almost on a daily basis, inquiries regarding the status of the court case. But since there is no way of predicting when such a decision will be made (nor its outcome), near-term financial pressures on US producers have been at odds with the producers' hope of a favorable judgment, and their desire to hold out for prices in excess of the Exchange Value plus the US premium.

Based on actions taken since Judge Carrigan's original ruling, it is clear that market participants anticipate that the original ruling will be upheld by the Appellate Court. As noted above, US utilities generally have done whatever they could to reduce the non-US fraction of their inventories, in case of a partial or total restriction on the use of imported

© NUEXCO 1987

uranium. Most have maximized their use of non-US-origin feed and continue to do so. Techniques include the purchasing of non-US material in order to save stocks of US-origin for use after the likely imposition of a limitation on the use of non-US-origin uranium. Some US utilities buying non-US uranium in the long-term market have included contract provisions that excuse them from purchasing to the extent that non-US-origin material cannot be used. Others have made use of internal or external location and origin swaps (including de-enrichment swaps) some of which have strained the regulatory process. Still others have simply bought US-origin and paid the premium, to ensure against later potential supply shortages or rapid price increases. Other entities, including non-US utilities, producers and traders also have made adjustments, and concluded transactions, in ways that presume restrictions on the import of non-US uranium.

Since there are as yet no *legal* requirements restricting the import of non-US-origin uranium into the USA, other than those imposed against southern African uranium as a result of the Comprehensive Anti-Apartheid Act of 1986, the US premium reflects buyers' and sellers' perceptions of future market conditions and events. The movement of the US premium (Figure 1) since it was introduced in December 1986 (Report 220) shows several market phases. First, the rise in premium reflects the emergence of preferred or required purchasing of US-origin by US utilities. The leveling off reflects the attainment of an equilibrium condition, and the subsequent decline reflects the fall-off in demand for US-origin associated with a gradual lessening of tension as the court decision continued unresolved, and US utility inventory became largely of US origin. The factors with the greatest influence over the premium for US-origin uranium remain the decision by the Appeals Court, and possible legislative action that would restrict imports.

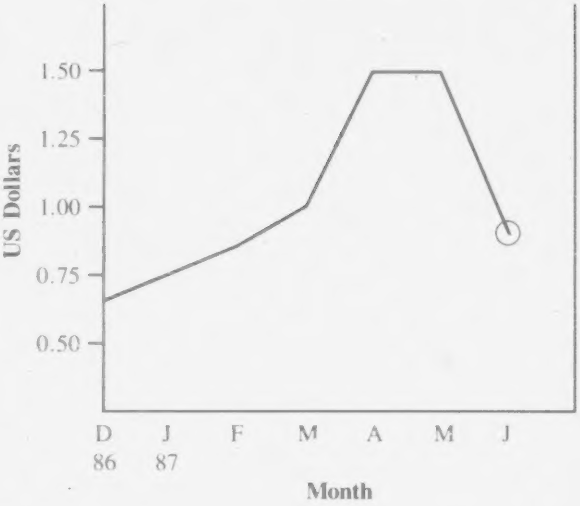
* * *

The UF_6 Value declined $0.25 this month, to $47.75 per kgU as UF_6. No transactions are reported involving natural UF_6, but two sales of low-enriched UF_6 were concluded, totaling over 250,000 pounds U_3O_8 equivalent. Demand for natural UF_6 remains unchanged since last month. Although available sales opportunities are relatively few, sellers appear slightly more aggressive than in past months, and the largely discretionary demand has resulted in a slight downward price movement. US-origin UF_6 still is relatively more abundant than US-origin U_3O_8. The premium (relative to the UF_6 Value) for US-origin UF_6 declined $0.75 to $2.25, following the general weakening in prices for US-origin material.

Figure 1

U S PREMIUM

(Relative to Exchange Value)



* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported. While some loan opportunities exist, the security requirements imposed by potential lenders on financially marginal borrowers have served to make most potential transactions uneconomic.

* * *

The Conversion Value is unchanged since last month at $1.80. No conversion transactions are reported, and the secondary market for conversion services remains relatively inactive. Supply of secondary market services is unchanged since last month, and what demand does exist is largely discretionary as to timing.

© NUEXCO 1987

ENRICHED URANIUM AND SWUS

The SWU Value declined to $75 per SWU this month. Two SWU transactions, totaling less than 100 thousand SWU, are reported in the *Current Market Data* section of the Report, all from purchases of low-enriched uranium. Weak demand caused a slight downward price pressure on the secondary SWU market during May, with only one buyer whose timing is discretionary in the market for a significant quantity of SWU. A number of potential sellers have yet to enter the market, and some are constrained by noncommercial factors from offering their SWU. They could enter the market at any time, adding substantial new quantities for sale. Any such entry could result in further downward pressure on SWU prices in the near future.

DOE-origin SWU currently is selling at a discount compared to Eurodif or Urenco SWU, because of concerns about a potential embargo on feeding non-US uranium for enrichment. European enrichers will likely always be able to take non-US-origin feed, while an embargo could limit the amount of non-US feed allowed for delivery to DOE for enrichment. In addition, prices of USSR-origin SWU remain significantly below those for western-origin SWU.

© NUEXCO 1987

CURRENT MARKET DATA

May 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$17.00**/lb. U_3O_8	4,080	1,375
UF_6 VALUE	**$47.75**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	580	0
SWU VALUE 0.3 tails assay; delivery within one year	$75/SWU		
LOAN RATE	3%/annum	1,000	500

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	17.20	3.1	17	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1987

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (May 31, 1987)**	**Last Month (Apr 30, 1987)**	**12 Months Ago (May 31, 1986)**	**This Month (May 31, 1987)**	**Last Month (Apr 30, 1987)**	**12 Months Ago (May 31, 1986)**
Australia (dollar)	23.84	26.15	23.64	61.97	67.97	61.47
Belgium (comm. franc)	640.30	631.50	796.25	1,665	1,642	2,070
Canada (dollar)	22.84	22.73	23.41	59.37	59.09	60.86
EEC (ecu)	14.90	14.72	18.04	38.75	38.26	46.92
Finland (markka)	74.79	74.46	89.62	194.44	193.59	232.98
France (franc)	102.97	101.49	124.82	267.69	263.86	324.49
FRG (mark)	30.82	30.45	39.21	80.12	79.16	101.93
Italy (lira)	22,269	21,778	26,759	57,894	56,618	69,567
Japan (yen)	2,433	2,366	2,923	6,326	6,152	7,599
Netherlands (guilder)	34.76	34.39	43.93	90.36	89.41	114.20
South Africa (rand)	34.34	34.03	39.44	89.29	88.48	102.54
Spain (peseta)	2,151	2,140	2,484	5,591	5,563	6,457
Sweden (krona)	107.59	106.65	123.91	279.72	277.27	322.13
Switzerland (franc)	25.55	24.96	32.46	66.43	64.88	84.39
UK (pound)	10.43	10.24	11.42	27.11	26.62	29.68
US (dollar)	17.00	17.00	17.00	44.20	44.20	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (May 31, 1987)**	**Last Month (Apr 30, 1987)**	**12 Months Ago (May 31, 1986)**	**This Month (May 31, 1987)**	**Last Month (Apr 30, 1987)**	**12 Months Ago (May 31, 1986)**
Australia (dollar)	24.12	26.15	23.85	67.70	67.97	62.01
Belgium (comm. franc)	647.83	631.50	803.28	1,684	1,642	2,088
Canada (dollar)	23.11	22.73	23.62	60.07	59.09	61.40
EEC (ecu)	15.08	14.72	18.20	39.20	38.26	47.33
Finland (markka)	75.67	74.46	90.41	196.73	193.59	235.04
France (franc)	104.18	101.49	125.92	270.84	263.86	327.36
FRG (mark)	31.18	30.45	39.55	81.07	79.16	102.83
Italy (lira)	22,531	21,778	26,995	58,575	56,618	70,181
Japan (yen)	2,462	2,366	2,949	6,401	6,152	7,666
Netherlands (guilder)	35.17	34.39	44.32	91.43	89.41	115.21
South Africa (rand)	34.75	34.03	39.79	90.34	88.48	103.45
Spain (peseta)	2,176	2,140	2,505	5,657	5,563	6,514
Sweden (krona)	108.86	106.65	125.00	283.01	277.27	324.97
Switzerland (franc)	25.85	24.96	32.75	67.21	64.88	85.14
UK (pound)	10.55	10.24	11.52	27.43	26.62	29.94
US (dollar)	17.20	17.00	17.15	44.72	44.20	44.59

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on May 29, 1987.

© NUEXCO 1987

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6 This Month (May 31, 1987)	per lb. U as UF_6 Last Month (Apr 30, 1987)	per lb. U as UF_6 12 Months Ago (May 31, 1986)	per kg. U as UF_6 This Month (May 31, 1987)	per kg. U as UF_6 Last Month (Apr 30, 1987)	per kg. U as UF_6 12 Months Ago (May 31, 1986)
Australia (dollar)	2.52	2.77	2.50	5.56	6.10	5.52
Belgium (comm. franc)	67.80	66.86	84.31	149.47	147.41	185.87
Canada (dollar)	2.42	2.41	2.48	5.33	5.31	5.46
EEC (ecu)	1.58	1.56	1.91	3.48	3.44	4.21
Finland (markka)	7.92	7.88	9.49	17.46	17.38	20.92
France (franc)	10.90	10.75	13.22	24.04	23.69	29.14
FRG (mark)	3.26	3.22	4.15	7.19	7.11	9.15
Italy (lira)	2,358	2,306	2,833	5,198	5,084	6,246
Japan (yen)	257.66	250.56	309.49	568.04	552.38	682.31
Netherlands (guilder)	3.68	3.64	4.65	8.11	8.03	10.25
South Africa (rand)	3.64	3.60	4.18	8.02	7.94	9.21
Spain (peseta)	227.70	226.56	262.97	502.00	499.47	579.74
Sweden (krona)	11.39	11.29	13.12	25.12	24.90	28.92
Switzerland (franc)	2.71	2.64	3.44	5.96	5.83	7.58
UK (pound)	1.10	1.08	1.21	2.43	2.39	2.67
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU VALUE delivery within one year (May 31, 1987)	UF_6 Value per kg.U in UF_6 This Month (May 31, 1987)	UF_6 Value per kg.U in UF_6 Last Month (Apr 30, 1987)
Australia (dollar)	105.16	66.95	73.82
Belgium (comm. franc)	2,825	1,798	1,783
Canada (dollar)	100.75	64.14	64.17
EEC (ecu)	65.76	41.86	41.55
Finland (markka)	329.96	210.07	210.24
France (franc)	454.27	289.21	286.56
FRG (mark)	135.97	86.56	85.97
Italy (lira)	98,245	62,549	61,491
Japan (yen)	10,736	6,835	6,682
Netherlands (guilder)	153.34	97.62	97.10
South Africa (rand)	151.52	96.46	96.09
Spain (peseta)	9,488	6,040	6,042
Sweden (krona)	474.68	302.21	301.12
Switzerland (franc)	112.73	71.77	70.46
UK (pound)	46.01	29.29	28.90
US (dollar)	75.00	47.75	48.00

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on May 29, 1987

© NUEXCO 1987

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
4038	1988	101-300	R[5]	Trader	Utility	Low-enriched UF_6
4045	1989-98	3,001-6,000	R[5]	Producer	Utility	
4051	1988	50-100	113	R[5]	Utility	US-origin.
4058	1988	101-300	103	Producer	Utility	
4059	1988	50-100	R[5]	Trader	Utility	Low-enriched UF_6
4060	1987	50-100	104	Producer	Utility	US-origin.

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.3% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4038B	1988	50-100	R[5]	Trader	Utility		Low-enriched UF_6
4059B	1988	less than 50	R[5]	Trader	Utility		Low-enriched UF_6

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(May 31, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2335	420	—	
2764	500	—	
2893A	720	—	UF_6
2933	300	300 per year	1988-90
2989	40	—	
2996*	200	500 per year	1988-90
3023	400	500	UF_6
3121*	500	—	
3166	50	—	
3238*	500	—	1988-90
3244*	250	300 per year	1988-93
3316*	200	—	
2263	—	400 per year	1989 on
2781	—	400 per year	1988-95
3123	—	2,000	1988
3171	—	200 per year	1988-92
TOTAL:	4,080		
INACTIVE			
2297	100	100 per year	1988-89
2967	1,000	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
TOTAL:	1,150		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2389, 2740, 2973, 3129, 3135

© NUEXCO 1987

URANIUM DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2911*	65	—	UF_6
3141*	130	—	
3149*	50	—	
3175	90	—	UF_6
3191*	390	—	
3216*	325	—	U_3O_8 or UF_6
3249*	150	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3120	—	1,000 per year	1988-91
3137	—	4,800 per year	1993-97
3147	—	200	1988-92
3193	—	700 per year	1989,91,94,96
TOTAL:	1,375		
INACTIVE			
2798	150	—	
2984*	260	—	U_3O_8 and UF_6
TOTAL:	410		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2760, 3192.

© NUEXCO 1987

LOAN SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
TOTAL:	1,000	—	
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		
Inquiries to borrow			
ACTIVE			
3206	500	—	
TOTAL:	500		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

© NUEXCO 1987

CONVERSION SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	 Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
3222	80	—	
2764B	500	—	
TOTAL:	580		
Available for Sale: INACTIVE			
2859	750	750	
3165	330	—	
TOTAL:	1,080		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: 2988

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(May 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Delivery Period[1] (Thousands of SWUs) Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571	55	—	1987
3173	45	—	1987
TOTAL:	100		
INACTIVE			
3213	150	—	
3322	150	—	
TOTAL:	300		
Inquiries to Purchase:			
ACTIVE			
2999	150	—	1987
3159	30	—	1987
TOTAL:	180		

---

*New or revised since last month

[1] Measured from the date of this Report

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts

Projects removed since last month: 2969, 3159, 3208.

© NUEXCO 1987

THE SECONDARY SWU MARKET IN THE 1990s

This article is an edited version of the speech given by Nuexco's Don W. Radcliffe, at the AIF International Conference: The Enrichment Marketplace in the 1990s, *in San Francisco, California, May 28, 1987.*

Introduction

The secondary market for enrichment services originated as a means to solve imbalances arising from plant cancellations and delays, which had been aggravated by DOE's inflexibility in allowing contract holders to reduce their commitments. The market grew as Eurodif shareholders sought an outlet in the USA for their excess commitments, helped by the strong position of the dollar versus European currencies. In 1983-1984, the US Department of Energy (DOE) introduced various versions of enrichment contracts, finally settling on the Utility Services enrichment contract (USEC). The overwhelming customer response to the USEC temporarily halted DOE's loss of market share to the secondary market and to Eurodif, and reduced the number of both buyers and sellers on the secondary market. DOE's competitive situation also was helped by the fall of the dollar, which has effectively reduced the flow of Eurodif SWU into the USA.

The secondary SWU market is expected to evolve into a "spot" market for excess capacity of primary producers after about 1990, when most currently identified excess SWU inventories should be sold. Major uncertainties exist, however, regarding DOE's future prices, and possible judicial or legislative intervention in the US enrichment business. The potential entry of private SWU suppliers adds another variable into the future situation.

Origins of the Secondary Market

The secondary SWU market began in the mid-1970s with DOE's assignments of Long-Term Fixed Commitment (LTFC) contracts. At the time, DOE (formerly the AEC) held a virtual world monopoly, and had ceased taking orders for new contracts, leaving a substantial number of planned nuclear plants with no enrichment supply. As units with LTFCs began to be canceled, a lively trade developed in assigning the contracts from the canceled units to those lacking contracts.

The next phase of the secondary market followed DOE's "open season" in 1975 and the change to the Adjustable Fixed Commitment (AFC) contract in 1978. Because the AFC required utilities to agree to five-year advance commitments, plant construction delays and cancellations created many excess commitments. To relieve the pressure, DOE allowed its AFC customers to reduce their commitments by the equivalent amount of DOE SWU bought on the secondary market. This created the demand necessary to fully establish a secondary market, and led to a number of deals to swap future delivery commitments, partly spurred by the desire of utilities with delayed plants to recoup advance payment credits. Secondary market prices were keyed to the DOE AFC prices, and discounts of $2 to $5 per SWU were common.

By 1980, numerous new plant cancellations and delays overwhelmed the near-term demand for SWU. Burdened with development costs, DOE failed to respond to this trend, maintaining high production levels, and refused to provide relief to AFC contract holders. This created a large inventory of excess SWU and a buyers' market with increasingly large discounts. Once these discounts reached about $30 per SWU, holders of DOE's 3.5-year requirements contract realized they could terminate their DOE deliveries, pay the 25 percent termination charges, and still benefit from buying on the secondary market. When contract holders also began to realize that by going short and terminating their requirements contracts ahead of time, they could save the termination charges, contract terminations started to snowball. Even some 5-year requirements contract holders used the technique, through creative accounting on their contract delivery ceilings.

As DOE watched its planned enrichment commitments slip away, trends in Europe further eroded DOE's market. With Eurodif running at high capacity, Europeans also developed inventories of excess SWU. Some Europeans took advantage of the then strong dollar to sell into the DOE market.

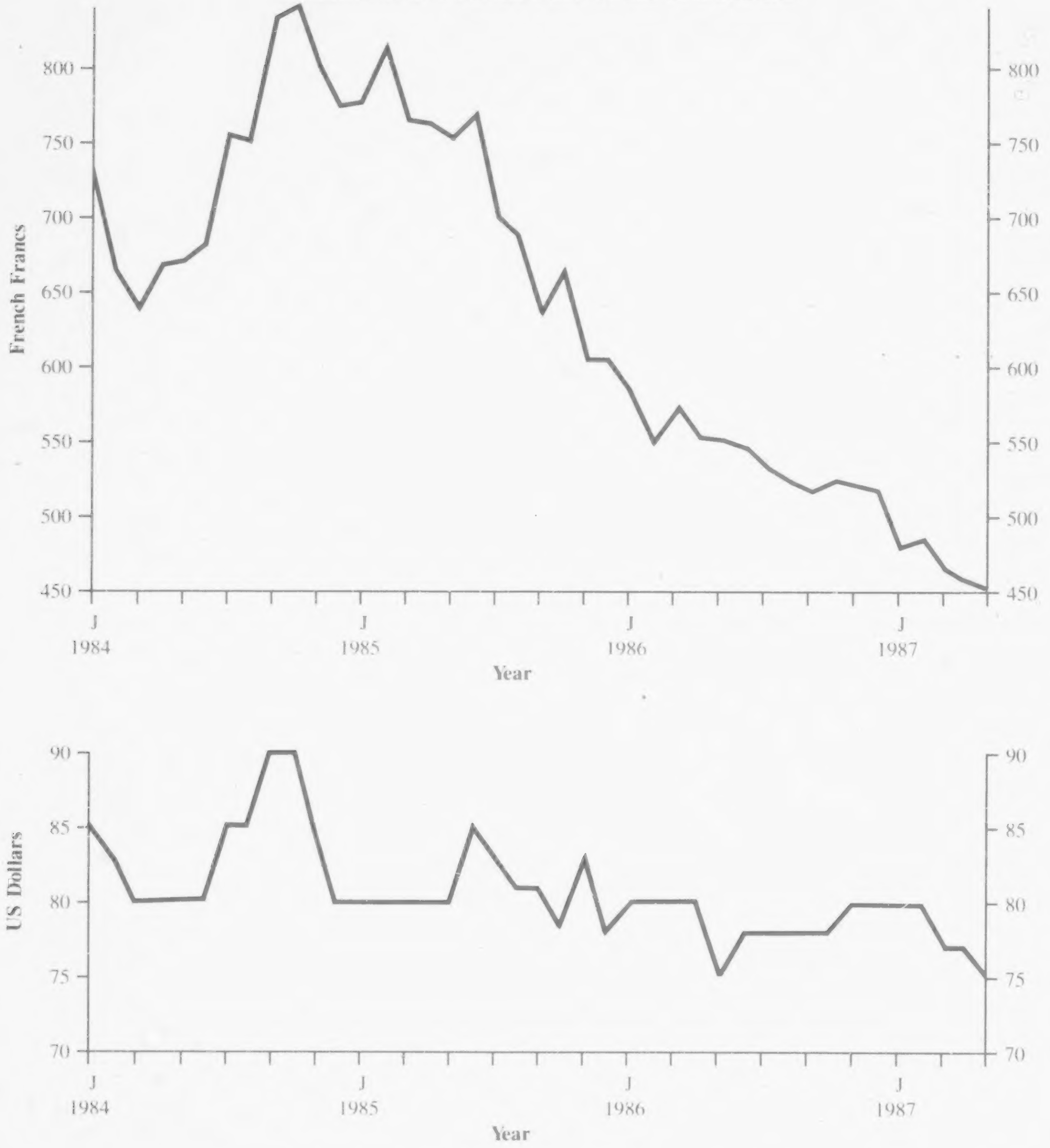
Initially, US utilities saw the purchasing and use of non-US SWU as risky. The market in European enrichment started slowly, with high discounts and requirements to stockpile SWU in the USA. As sellers of Eurodif SWU established their credibility, increased US buying cost DOE 25 percent of its market share. DOE responded by offering the Interim Sales Contract, which allowed requirements contract holders a reduced price if they would stay with DOE, but this just triggered another round of price cuts by European sellers.

DOE's next attempt to keep its position was the Modified Interim Sales Contract, which permitted requirements contract holders to buy 40 to 60 percent of their needs on the

© NUEXCO 1987

Figure 2

SECONDARY MARKET SWU PRICES
(NUEXCO SWU VALUES)
EXPRESSED IN FRENCH FRANCS and US DOLLARS



©NUEXCO 1987

secondary market without termination penalties, as long as the SWU were certified to be DOE origin, but this offer also met with limited success.

In 1984 DOE made four major changes, embodied in the new Utility Services Enrichment Contract (USEC):

1. higher termination charges;
2. reduced prices and a guaranteed price ceiling;
3. requirements-based contracting to eliminate excess SWU; and
4. allowance for customers to buy up to 30 percent of their requirements outside DOE.

Customer acceptance of the USEC exceeded even DOE's projections, representing over 80 percent of DOE customers and covering more than 90 percent of their projected demand. The following year, DOE succeeded in removing most of its customers' uncommitted requirements from the secondary market through the Incentive Price SWU offer. The Incentive Price offer allowed DOE customers to fill their uncommitted requirements from DOE at $90 per SWU for 1987 and 1988 deliveries, and $90 with escalation for 1989 and 1990. To further consolidate its market share, DOE made a second Incentive Price offer at $85 per SWU plus escalation for 1991 to 1995 deliveries. While not as successful as the first, the second offer still was accepted by a majority of DOE's customers.

The USEC has been called an "overkill" solution, as the supply of Eurodif-origin SWU for sale on the secondary market already had been decreasing as the new terms were introduced. Considering that the USEC's introduction has cut DOE's annual revenues by over 40 percent, it is not surprising that customers found it attractive, particularly the AFC customers.

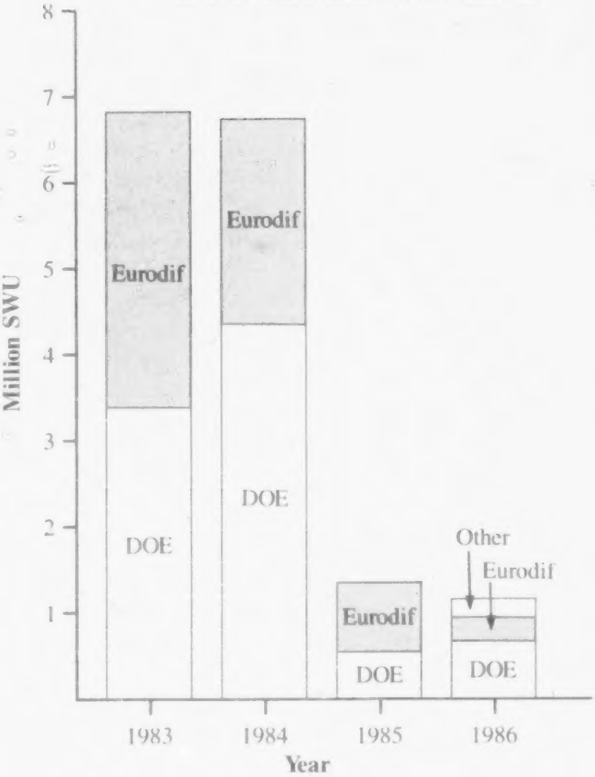
Since introduction of the USEC, DOE's competitive position has been helped by the drastic decline of the US dollar against the European and Japanese currencies since 1984. Figure 2 shows the 40 percent fall in secondary market prices since 1984 as expressed in terms of the French franc. Secondary market SWU prices expressed in other European currencies declined similarly. While in 1983, Eurodif shareholders were motivated to sell because they could receive prices above their incremental costs of production, this situation currently is reversed, with DOE incentive prices below Eurodif production costs.

The Future of the Secondary Market

Given the success of the USEC in eliminating the majority of secondary market buyers and sellers, what is the future of the secondary SWU market? Compared to the peak activity of 1983 and 1984, the market is relatively quiet. As shown in Figure 3, annual sales in the secondary market dropped from over six million SWU in 1983 and 1984 to about one million SWU in 1985 and 1986.

Figure 3

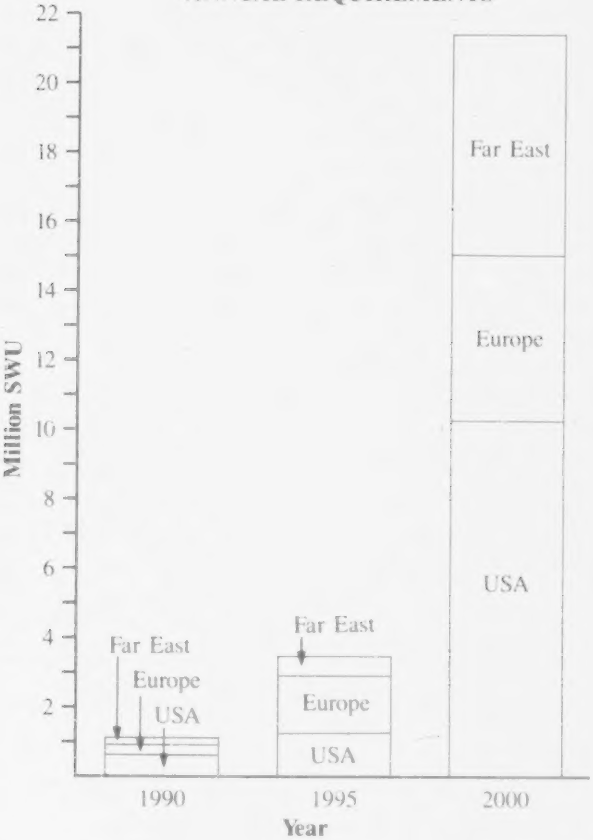
SECONDARY SWU MARKET ANNUAL TRANSACTION VOLUME



Today's secondary SWU market is a buyers' market, with demand from the few utilities which have uncontracted requirements outweighed by the available supply of secondary market SWU. Assuming no cancellations of existing contracts, uncontracted requirements are expected to absorb less than one million SWU per year through 1990, with the majority of this demand coming from US utilities (Figure 4). After 1990, DOE customers that did not accept the second incentive price offer, plus Eurodif, Urenco, and Techsnabexport customers whose contracts expire, gradually will

Figure 4

UNCONTRACTED SWU ANNUAL REQUIREMENTS



increase the potential demand to about four million SWU per year in 1995. Many of these customers are committed to national suppliers, and are expected to extend existing contract obligations. After 1995, however, nearly two-thirds of the western world's SWU demand, or over 20 million SWU per year, still is not committed and could be purchased on the the spot or secondary market.

The sellers in today's market are those that hold excess inventory or delivery commitments, plus primary producers such as the USSR, that are willing to sell on the spot market. There are about 25 million SWU currently in utility inventories, representing approximately one year's requirements for the entire western world. Of these SWU, from 2 to 5 million are likely to be sold as excess in the next five years. The quantity sold will depend largely on customers' expectations of future DOE pricing policy; if those customers expect prices to maintain the current downward trend, more utilities will decide to sell. The USSR's enrichment export company, Techsnabexport, also is active in the spot market, selling primarily to European customers. Buying SWU from the USSR is viewed as risky by some utilities, in the same way as buying European SWU appeared risky in the early 1980s. However, the USSR's costs are perhaps the lowest in the world, their prices are attractive, and a history of reliable deliveries will help break down these perceived barriers.

After 1990, most of the currently identified excess inventories should be sold, and to the extent it exists, the "secondary" SWU market will likely evolve into a "spot" market for primary SWU suppliers with excess production capacity. The current Eurodif shareholder contracts are due to be renegotiated for deliveries after 1990. Today, it is uncertain whether Eurodif production will continue at reduced levels, or whether shareholders with reduced nuclear programs will emerge from these negotiations with additional SWU that must be sold on the secondary market.

Conditions in the 1990s should be more favorable for secondary market sellers, but the DOE incentive price probably will still put an upper limit on secondary market pricing. Excess production capacity will exist through the end of the century, even without further capacity additions (Figure 5). Any additional privately produced SWU will add to the excess capacity and will have to displace current production capacity.

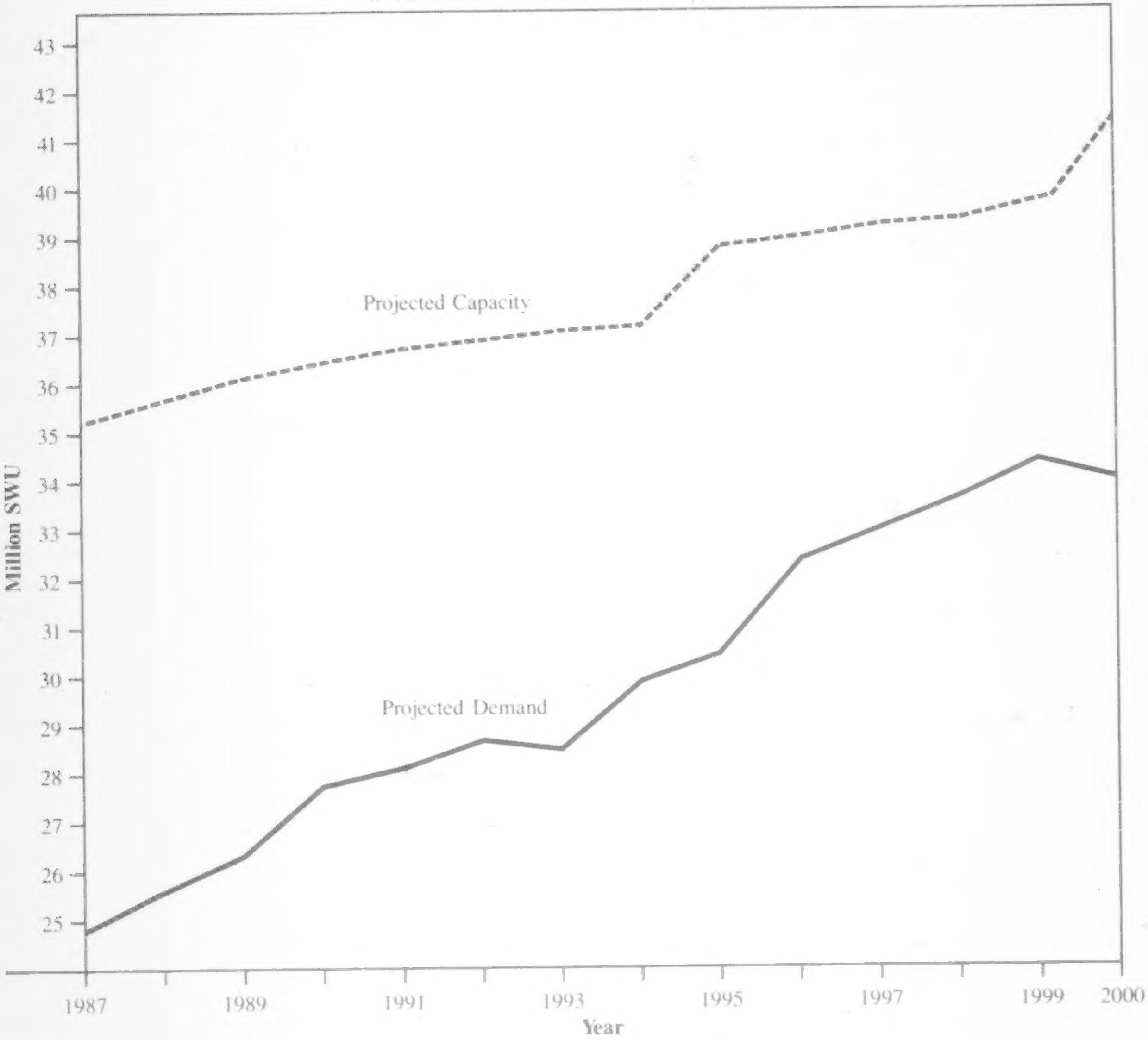
While the above forecasts of supply and demand would indicate that the secondary market will play a relatively small role in the 1990s, it is probable that the primary SWU market will be inefficient enough to create additional opportunities. On closer inspection, the foregoing forecasts rest on unstable economic and political ground. For example, most of the customers who converted to the USEC are satisfied with results to date, but now are concerned with the future of the DOE enrichment enterprise.

Major uncertainties for USEC contract holders include DOE's debt repayment and TVA's demand charges, which could cost up to $10 billion. While DOE has reduced prices over the last few years to support their market strategy, it is hard to see how DOE can continue doing this. DOE's current price structure is based on liquidating inventories that were produced in previous years at lower costs. Those inventories are predicted to run out after FY88, leading to a potential cash flow crisis if the TVA situation is not resolved, and DOE is again asking Congress for assistance.

© NUEXCO 1987

Figure 5

SWU CAPACITY AND DEMAND, 1987-2000



ANALYSIS & COMMENTARY

In addition to price concerns, there are pending sanctions and court cases which could limit or prohibit DOE from enriching non-US-origin uranium for US customers and southern African uranium for non-US customers. Even some US utilities are questioning the reliability of DOE as a supplier and demanding discounts for secondary market DOE-origin SWU. If the potential legislative or judicial restrictions are realized, they will create significant new supply and demand in the secondary market.

Changes in Utility Structure

Several fundamental changes could affect both the primary and secondary SWU markets, such as basic changes in the structure and buying patterns of SWU customers, evolution of new technology, and entry into the market of private enrichment suppliers. There currently are only two utilities in the world which purchase all of their SWU requirements on the spot market. Their strategy has been quite successful; as spot market buyers, they have been able to purchase their enrichment services at discounts of 30 to 40 percent below long-term contract prices and 10 to 20 percent below DOE incentive prices. Given the savings that are possible by buying in the spot market, and forecasts of continuing overcapacity, one may wonder why any DOE requirements contract holders signed the USEC, and whether utilities are likely to sign long term contracts again in the future. The answer, at least in the USA, lies in the current utility regulatory structure, which allows utilities to pass on all "prudent" costs, and discourages risk taking. Essentially, this means that the utility rate commissions pass on any savings to the ratepayers, but charge the utility shareholders with any mistakes. Since the commissions will never question the cost of DOE SWU, utilities have little incentive to make the extra effort needed to shop around for lower cost enrichment.

It seems likely that this purchasing mentality on the part of utilities, and its inherent economic inefficiency, will not continue into the 1990s. The "pass through" cost recovery structure, along with the utility monopoly on power generation, are being phased out. More electric power will be sold in a competitive market, where the utility which saves 30 percent on enrichment costs can either keep the money or reduce its electricity prices to enlarge its market share. Such a pricing structure already is in effect with Public Service of Colorado's Fort St. Vrain plant, and it has been proposed for Commonwealth Edison's Byron and Braidwood units and Pacific Gas and Electric's Diablo Canyon units.

Over the past several years, purchasing attitudes toward the secondary market and non-DOE SWU have been permanently changed. While only two utilities are willing to depend on the secondary market for their total enrichment supply, others now see it as a supplemental tool in their overall strategy to reduce fuel costs.

New Technology

Centrifuge enrichment technology is very capital intensive compared to the older gaseous diffusion process, but it has relatively low incremental operating costs. Nuexco estimates show diffusion plants' current operating costs to be in the range of $50 to $90 per SWU, and capital costs from $20 to $30 per SWU. By comparison, a centrifuge plant's cost structure would be reversed, with operating costs between $20 to $35 per SWU, including centrifuge replacement, and capital costs between $60 to $80 per SWU. The Atomic Vapor Laser Isotope Separation (AVLIS) process is projected to have both low operating and capital costs, perhaps $20 per SWU for each. Once a centrifuge or AVLIS plant is operating, any uncontracted production capacity will likely be very competitive on the spot market, where recovery of full capital costs is not necessary.

While plants using the new technologies will be most efficient at full capacity, their utility customers need enrichment flexibility due to the unpredictable nature of their fuel requirements. The spot market would fill a need here, as it has in the uranium business. Facilities with low operating costs could either overcommit their production and fill their peak needs with spot market purchases, or size their facilities for peak loads and sell the excess in the spot market. The Urenco facilities currently are fully loaded under their long term contracts, but if Urenco is unable to deliver its planned production to customers, we would expect to see those customers in the spot or secondary market.

Privatization of the US Enrichment Business

For purposes of this discussion, privatization of enrichment services in the USA does not mean a government-corporation takeover of the existing DOE gaseous diffusion enrichment facilities. Under such an action, the corporation would merely inherit many of the problems facing the current DOE enrichment enterprise. It would take over an operation with high incremental costs, high sensitivity to energy prices, operating at a low fraction of capacity, and with customers who have been promised SWU prices below cost. If the dollar remains weak, this "private" corporation would be able to compete effectively with Eurodif, and its cost structure would support requirements contracts. However, this corporation could not be expected to introduce renewed competition into the enrichment industry, as it will likely delay the introduction of new technology in order to protect its investment in the existing diffusion plants.

True privatization requires the construction or completion of new enrichment facilities by private entities not connected to the US government. Examples of this are the American Enrichment Company's proposal to complete and operate the existing DOE Gas Centrifuge Enrichment Plant (GCEP) facility, and Urenco's idea of building a new centrifuge plant in the USA. If allowed, these plants could be in operation by about 1995, or perhaps even earlier if market conditions warrant. Unless the prospective private enrichment facility can and will sell SWU at a price lower than DOE's incremental costs of production, it shouldn't even try to enter the business.

The primary obstacle to the entry of a private enrichment company is the lack of a market. The total uncontracted demand (Figure 4) will have to be divided between existing primary enrichers, the secondary market, and the private enrichment services. Until their reliability is established, private enrichers probably will have to sell at secondary market prices, which will reduce their profit margins. However, without the secondary market the private enrichers may have no market at all. Even in the absence of a secondary market, private enrichment services still probably would have to meet DOE's incentive prices to capture any business.

There is even a possibility that existing primary suppliers will buy in the secondary market or from private producers to meet their contractual commitments if prices are lower than their incremental costs. This situation occurred in the uranium market in the early 1980s, but it is unlikely for SWU, considering the political pressures that will probably be exerted to keep the government plants open.

Gas centrifuge enrichment plants have high fixed costs. The private companies which use this technology certainly will attempt to obtain fixed commitment contracts at fixed prices, to reduce the financial risks. However, this may not be possible in the current buyers' market. To enter the business, private companies will have to have adequate financial backing to construct enrichment plants without guarantees of future income. This could be an insurmountable hurdle without government intervention in the form of financial guarantees. But assuming that their operation is assured, the secondary market will be one of the best vehicles for those suppliers to aggressively build market share.

Choices for the Future

The entry of at least one new company into the US enrichment field will be required to give customers the benefit of healthy competition. It is very unlikely that any new player will be able to assure its financial backers of income for at least 5 and perhaps 10 years, and even then, technical obstacles and potential government policy changes, under yet-to-be elected administrations, introduce additional risks. Yet, without the emergence of a new company, most DOE customers will not terminate their USEC contracts, further reducing the potential market for the 1990s.

It is obvious that the US government must decide on a consistent long-term strategy for its enrichment enterprise. It could simply harvest its business, by increasing prices and eliminating research. Or, by reducing prices and developing low cost processes it could maintain its overall market share with little change. A third alternative would be to expand, by undercutting prices and aggressively developing new processes. Today, by reducing prices, but eliminating research and development, DOE seems to have no strategy. If, however, DOE decides to maintain or expand its business, then there will be little room for private investment in enrichment.

If the US objective is to maintain enrichment capability and technology leadership, the best strategy might be to harvest the investment in its existing diffusion plants, providing the best economic return on that investment, while giving private industry incentives to develop a more cost efficient technology. This could take the form of an agreement similar to that for co-generated power, to purchase all of the SWU produced by the private enrichers at a price equal to the incremental costs of diffusion enrichment. Given a base load with DOE, private producers would be able to obtain lower-cost financing and compete aggressively in the world secondary market. They could then establish their credibility as the primary market is opening up in the mid-1990s.

Conclusion

In the 1970s, the assignment of utilities' Adjustable Fixed Commitment contracts created a market to provide an efficient means for exchange of SWU delivery commitments between utilities with excess and those with needs. In the same way, the secondary SWU market was a result of excess SWU produced under fixed commitment contracts, both by DOE and by Eurodif.

Today, both DOE and Eurodif have cut back production to reduce excess SWU, reducing the need for this secondary market. The secondary market's current function is to provide a mechanism for transferring the remaining excess inventories and purchase commitments and, to some extent, for selling USSR-produced SWU. In the 1990s, the secondary market may evolve into a spot market for selling SWU from the USSR and from other unestablished but low cost sources, such as private producers.

The primary SWU business still is in the hands of governments and government-owned corporations. Its history has shown that when governments try to set policy using commercial enterprises, they can generate gross economic inefficiencies. These same governments may again produce the inefficiencies which sustain the existence of a major secondary market.

Utilities which have not signed long-term contracts have realized reductions of up to 40 percent in their enrichment costs through participation in the secondary SWU market. For this reason, all utilities should consider reducing their long-term contract commitments so that they can continue to take advantage of the secondary market and the excess production capacity in the primary market.

© NUEXCO 1987

JAPAN

Seven Japanese utilities recently have concluded their annual price negotiations with South Africa's Nuclear Fuels Corporation (NUFCOR), for uranium delivered under long-term supply contracts. The utilities agreed to pay approximately US$ 30.50 per pound U_3O_8 for fiscal year 1988 deliveries (ending March 31, 1989), the same price agreed upon last year for FY87 deliveries. The agreement was a compromise following a temporary breakdown in negotiations; NUFCOR had wanted to increase the price, despite the continuation of low spot prices, possibly hoping to take advantage of the continuing strength of the Japanese yen relative to the US dollar.

The annual price negotiations are influenced by spot and near-term uranium prices prevailing over the previous year, and the limited movement in prices provided insufficient rationale for raising the negotiated price. During the period covered by delivery contracts for FY82 to FY87, the negotiated delivery prices have dropped from $37.75 to $30.50. Table 1 shows a comparison of annually negotiated prices to average Nuexco Exchange Values for the past eight years.

* * *

Tokyo Electric Power Company (TEPCO) has announced firm plans to begin construction of Kashiwazaki-Kariwa Units 6 and 7 in 1991 and 1993, respectively. TEPCO has chosen General Electric Corporation's (GE) advanced BWR design for the plants, which together are estimated to cost approximately $4.5 billion. GE will provide the nuclear boiler systems, turbine generators, and the initial cores, at a cost of about $1 billion.

The 1,356 MWe (gross) plants will be the largest capacity BWRs outside the USSR, exceeded in size only by the 1,500 MWe RBMK unit at Ignalino in the USSR. Of its 32 commercial nuclear plants, Japan currently operates 16 BWRs based on earlier GE designs, which GE licensed to Toshiba and Hitachi for construction. The current order is part of a long-term development venture between GE and the two Japanese firms, and incorporates internal recirculation pumps that eliminate the requirement for large external recirculation pumps and piping.

The Ministry of International Trade and Industry (MITI) in April approved the installation program for TEPCO's Kashiwazaki-Kariwa Units 3 and 4 (1,100 MWe BWRs), which are scheduled for construction in July 1987 and February 1988, respectively. TEPCO expects the units to begin operating in July 1993 and July 1994.

Table 1

RESULTS OF ANNUAL JAPANESE-NUFCOR URANIUM PRICE NEGOTIATIONS COMPARED TO NUEXCO EXCHANGE VALUE

Fiscal Year Starting April 1	Approximate Agreed Price ($/lb. U_3O_8)	Average E.V. for Preceding Year ($/lb. U_3O_8)	Ratio of Delivery Price to Average E.V.
1981	45.00	41.17	1.1
1982	37.75	28.63	1.3
1983	35.50	23.65	1.5
1984	33.70	19.65	1.7
1985	33.50	22.10	1.5
1986	32.50	16.44	2.0
1987	30.50	15.94	1.9
1988	30.50	16.12	1.9

© NUEXCO 1987

* * *

Japanese utilities' profitability increased substantially during fiscal year 1986, ending March 31, 1987. Average pre-tax profits increased by more than 25 percent over the previous fiscal year (Table 2). Chubu Electric Power Company (EPC) showed the highest increase in profit level since FY85, 56.8 percent, and Tohoku EPC reported a 41.2 percent increase. Only Chugoku and Hokuriku EPC's profitability declined compared to the previous fiscal year. A large part of this profit, however, is due to the steady rise in the yen over the past year, and the related decline of the US dollar, which effectively have reduced dollar-denominated costs, such as oil, while leaving a greater percentage of revenues (in yen) for profit. This phenomenon is not expected to continue in the future. Despite much increased profits, overall sales of electricity declined more than two percent, primarily to Japan's industrial sector.

Table 2

JAPANESE UTILITY FY86 PROFITS[1]

Electric Power Company, Inc. (EPC)	Pre-tax Profit in FY ended 3/31/87	Profit Compared with Previous Fiscal Year (percent)	Gain Due to Yen/Dollar Exchange Rate
Hokkaido	439	+ 26.0	210
Tohoku	1,260	+ 41.2	1,367
TEPCO	4,440	+ 29.1	6,532
Chubu	3,226	+ 56.8	4,120
Hokuriku	453	− 17.8	394
Kansai	2,791	+ 21.2	2,720
Chugoku	701	− 12.5	930
Shikoku	510	+ 2.7	367
Kyushu	1,132	+ 12.0	1,055
Total/Average	**14,957**	**+ 25.6**	**17,695**

[1] All prices in 100 million yen

DECOMMISSIONING OF NUCLEAR PLANTS, Part 1

Introduction

Between now and the end of the century, nuclear plant decommissioning will become an issue of increasing importance to the nuclear power industry, and to the public in those countries that employ nuclear energy. By the year 2000, more than fifty currently operating commercial nuclear plants will have been in operation more than 30 years, and eight others will have exceeded forty years of operation. It is possible that many plants will be able to secure extensions to their operating licenses, enabling them to operate for additional periods. However, the economic, social, and political variables that could influence the granting, or even the desirability, of such extensions are difficult to predict.

At present, there are ongoing decommissioning projects in several countries, particularly in Canada, France, the Federal Republic of Germany (FRG), Japan, the United Kingdom (UK) and the USA. However, the projects currently being undertaken, while valuable for development of technology and experience, tend to involve much smaller, less radioactive situations than will be found in dealing with large commercial units.

Because much of the radioactivity found in nuclear plants will decay to near background levels within the first 100 years after shutdown, one much-discussed option involves entombing, or sealing the plant's reactor in concrete for up to 100 years or more. Another option is called "safe-storage," in which the unit is partially dismantled and decontaminated, and guarded for 40 to 50 years, before attempting to segment and remove the reactor's pressure vessel, internal parts, and containment structure.

At present, public awareness and understanding of the details of nuclear plant decommissioning is limited, and the public's reaction to such long-term choices is unknown. Immediate dismantling, however, poses the greatest radiation risks to the public and may not be technically achievable or economically feasible for some time, at least where large commercial power reactors are concerned. In addition, the problems posed by waste disposal have not been solved, either in the USA or in most other nuclear nations. Part One of this article examines past, present and near-future decommissioning projects in several countries, and discusses social and political trends that could affect continuing nuclear plant operations.

Stages in Plant Decommissioning

The word *decommissioning* is rather vague, and often is used to describe a wide variety of possible plant conditions following final reactor shutdown, over what is potentially a very long period of time. A given plant may alternate several times between phases of active work, in which equipment is being removed, decontaminated, and hauled away for disposal, and times when no work is being done. To add to the confusion, some persons or organizations may refer to a plant as *undergoing decommissioning* as soon as final shutdown takes place, while others may use the phrase only while work is actively being done. At any rate, the decommissioning process seldom is a smooth chronological sequence going straight through from plant shutdown to final removal of the last piece of equipment or structure. This article considers the process of decommissioning to begin with final fuel removal, continuing through complete removal of all equipment and structures until the site can be released for unrestricted access.

The owners of a nuclear plant may decide to terminate its operation, and therefore decommission the unit, for many reasons. The plant's operating licence may expire, and possible extensions may not be realistic or economic due to extensive necessary repairs, or upgrading for regulatory reasons. A plant may have become only marginally profitable to operate, or its small size may not be cost-effective relative to larger, more modern units. In some cases, equipment failure or other incidents may have reduced capacity, and repairs are too expensive to justify. Or, social pressures against nuclear power may result in governmental decisions to terminate operations at certain plants, either at the end of a license period or on some arbitrary timetable.

Much of the recent literature on decommissioning uses the concept of three standard phases, or stages, to categorize levels of decommissioning of a nuclear plant. Some plans only include activity up to a certain stage, with scheduling of further stages deferred, perhaps indefinitely.

Stage I begins immediately following plant shutdown, and includes removal of the reactor's fuel and securing of the plant for an indefinite period in a non-operating condition. The reactor's systems are drained of liquids (or gases), and most of the plant's electrical and mechanical equipment is taken permanently out of service. The mechanical openings to the containment structure are sealed, and the atmosphere inside the containment is controlled. Some decontamination of auxiliary systems or areas may be undertaken. Basically, Stage I refers to "mothballing" because little actual equipment removal is attempted. Access to the reactor and reactor site is controlled, with the operators maintaining regular monitoring and surveillance of the radiological and physical plant environs.

Leaving a reactor at Stage I for a chosen period of time requires less initial work, lower initial costs, and should result in lower occupational radiation exposures compared to

© NUEXCO 1987

quickly proceeding further in the decommissioning process. However, the long-term continued restriction of access to the site, and the relatively high level of continuing surveillance and monitoring are disadvantages.

In *Stage 2*, all equipment and some or all buildings external to the biological shielding are removed, and decontaminated if necessary, and reactor fuel is removed from the site. In this condition, plant activity, including monitoring, maintenance, and other normal activities, can be greatly reduced. The containment structure may be maintained intact as the principal barrier to access, or it may be decontaminated and removed, as deemed necessary for radiological safety.

It is at this stage that *entombment* may be chosen as an option for long-term storage. Entombing the reactor usually means sealing it in reinforced concrete or some other material until radioactivity has diminished to the point where workers can carry out many operations without the need for remote-controlled equipment (probably about 100 years after plant shutdown). Entombment may include the containment building, but more usually means sealing the reactor pressure vessel and its external shielding, allowing most or all external equipment to be removed.

Stage 3 represents the total dismantling and removal of the complete plant, including the reactor vessel and its internal parts, and disposing of all materials. The site may then be released for general, unrestricted use.

Full decommissioning assumes that most or all plants to be decommissioned will be taken through Stage 3, and eventually be completely removed. Simply describing the stages, however, does not account for the various possible timeframes leading to the Stage 3 condition. Even "immediate" dismantlement, for example, implies only that disassembling the reactor occurs within 10 to 15 years after shutdown. Following fuel removal, the owner could choose to store the reactor for long periods between the various states of disassembly. In particular, once the procedure reaches the Stage 2 condition — an intermediate level of disassembly — the owner may decide to maintain the reactor for a prolonged period in that condition, or entomb the plant, awaiting eventual dismantlement.

The three stages each present different advantages and disadvantages of cost, radiation exposure, political and social acceptability, and regulatory compliance. Of the three options, immediate dismantlement poses the greatest radiation risk to the public, the greatest technical challenges, and therefore the highest costs. Technically, the most attractive alternatives are those providing for a natural decrease in radiation to a point where remote-controlled equipment is only needed for limited operations. However, the long periods of entombment or long-term storage could provoke a significant social controversy.

Near-Term Decommissioning Possibilities

In the first decade of commercial nuclear power, from 1956 to 1965, 27 commercial reactors entered service in the West. Of these units, twenty were built in the UK, three in France, and two each were built in the USA and Italy (the USSR also built eight commercial reactors during that time). These early plants are small by today's standards and for technical reasons, most of these first-generation nuclear units are not likely to operate beyond their license periods and design lifetimes (typically 30 to 40 years). In the UK, particularly, a number of plants may have to be retired in the near future if license extensions are not granted. It is possible that many of these first-generation plants will be removed from service by the end of the century.

As a result of the boom in plant orders in the 1960s, between 1966 and 1975 over a hundred nuclear power plants entered commercial operation in the western world. Improved materials, advances in plant design and economics allowed and motivated the building of increasingly larger plants. These improvements may possibly allow extensions in operating lives, which in turn would delay the time before decommissioning is required.

During the third nuclear decade, from 1976 to 1985, nearly 170 more units entered commercial operation in the western world. Table 3 shows numbers of currently operating plants, by country, that entered service during the period 1955 to 1985. Figure 6 shows numbers of plants (operating as of the end of 1986) that will have exceeded 30 and 40 years of commercial service in years to come.

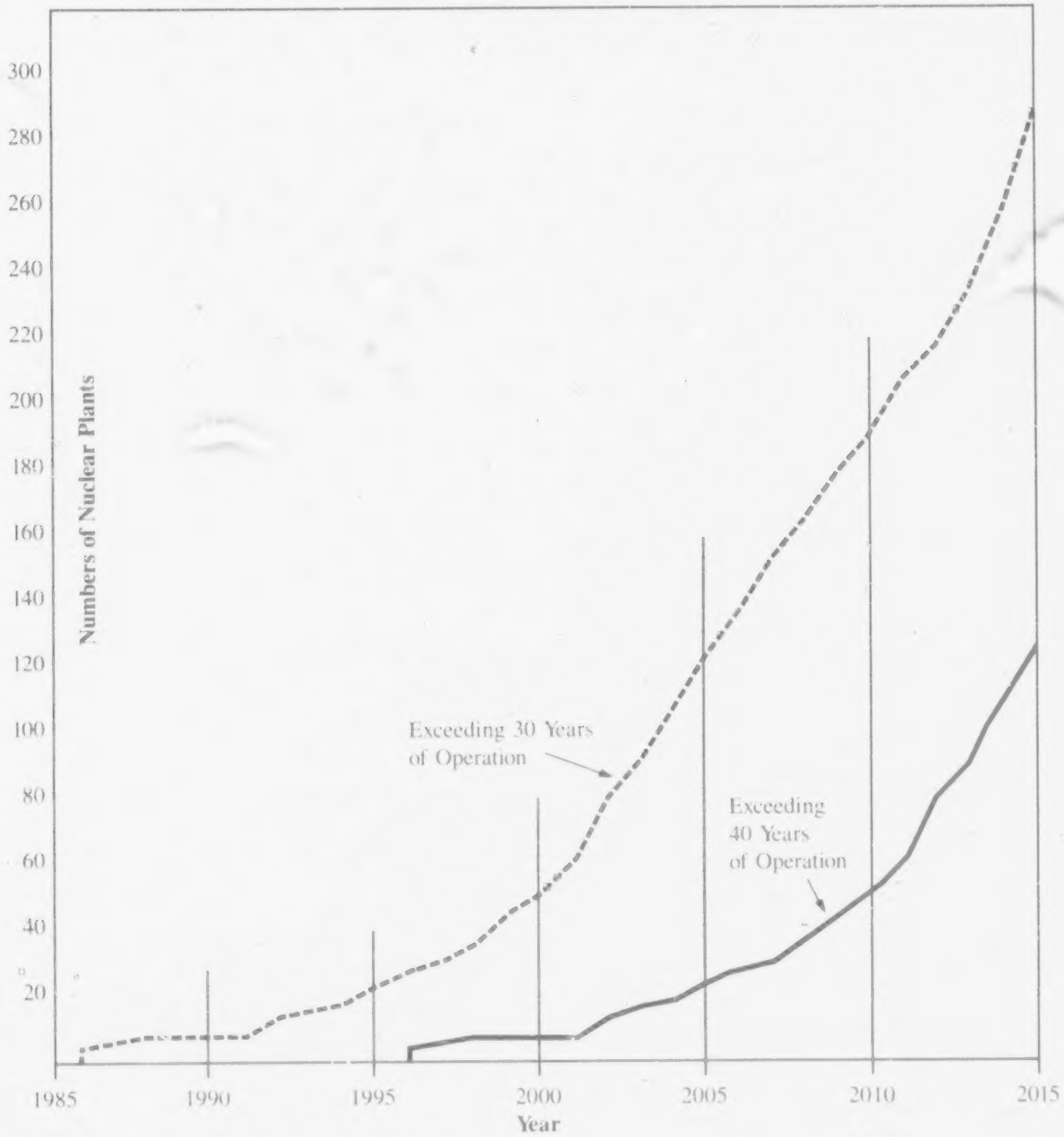
Assuming that none of the plants now operating are retired before 2000, there would be, by that date, over 50 plants whose operating age exceeded 30 years. Eight of those, all in the UK, would be over 40 years old. By 2010, almost 200 of the plants now operating will be over 30 years old, and more than 50 of today's plants will have seen greater than 40 years of operation. By 2015, nearly 300 commercial reactors will have exceeded the 30-year figure, and about 125 of those will then be over 40 years old. Thus, even if plants are able to reach 40 years of operation, there still will be a large number of units nearing retirement in the first decade of the next century.

Decommissioning Projects — Past and Present

To date, over sixty reactors have been partly or fully decommissioned in the USA alone, in addition to at least forty in other countries. Most of these units were small research or test reactors a fraction of the size of today's large commercial units, and few of these have been fully dismantled. The preferred options have been mothballing or

Figure 6

NUMBERS OF CURRENTLY OPERATING NUCLEAR POWER PLANTS WHOSE OPERATING LIFETIME WILL EXCEED 30 AND 40 YEARS BY 2015



entombment. Table 4 lists some of the decommissioning projects that have been carried out to a given, planned stage; Table 5 lists some projects undergoing or awaiting decommissioning.

Canada — Two Canadian reactors have been undergoing decommissioning, Hydro Quebec's Gentilly Unit 1 (250-MWe CANDU), and Ontario Hydro's Douglas Point (235-MWe CANDU). Both units were built by Atomic Energy of Canada Limited (AECL). Gentilly Unit 1 began commercial operation as a prototype in 1971 and operated intermittently until 1979, when the need for repairs caused the plant's shutdown. In 1983, AECL decided to decommission the unit by sealing off the reactor building, bringing the plant to a "static state." Since completion of this Phase 1 condition in 1986, AECL anticipates deferral of dismantlement for at least 50 years. The Douglas Point reactor operated from 1968 to 1982. Decommissioning started in 1985, and spent fuel is scheduled for transfer to storage canisters in mid-1987.

Table 3

CURRENTLY OPERATING NUCLEAR PLANTS[1] ENTRY INTO COMMERCIAL SERVICE, 1955 to 1985

Country[2]	1955-1965	1966-1975	1976-1985
Argentina		1	1
Belgium		3	4
Brazil			1
Canada		4	10
Finland			4
France		6	34
FRG		7	14
India		3	3
Italy	2		1
Japan		10	23
Korea			4
Netherlands		2	
Pakistan		1	
South Africa			2
Spain		3	5
Sweden		4	8
Switzerland		3	2
Taiwan			6
United Kingdom	20	7	10
USA	2	49	37
TOTAL:	24	103	169

[1] Does not include nuclear power plants that have been taken out of service or decommissioned.

[2] Includes only the World Outside the Centrally Planned Economies Areas (WOCA) countries.

France — The French reactor program includes a number of past, present and future decommissioning projects. Some of the major projects include the following:

1. Electricite de France's Unit G-1, a carbon dioxide-cooled heavy water-moderated reactor at Marcoule (46-MWt GCR), operated from 1956 to 1975. Decommissioning through Stage 2 will take place between 1986 and 1990.
2. The Marcoule station's G-2 and G-3 units (40-MWe GCRs) operated from 1958 to 1980 and from 1959 to 1984, respectively. Unit G-2 is scheduled to begin decommissioning in 1990 and Unit G-3 in 1995, both to the Stage 2 condition.
3. The Rapsodie 40-MWt fast breeder experimental reactor also is expected to undergo decommissioning procedures between 1987 and 1990. It entered service in 1967 and was shut down in 1982.
4. Chinon Unit A1 (80-MWe GCR) began operation in 1963 and was shut down in 1973. The reactor building and piping have been isolated, and the unit currently is at Stage 1 condition.
5. Chinon Unit A2 (230-MWe GCR) operated from 1964 to 1985. Plans for its decommissioning have not been made public.

Other French reactors involved in, or scheduled for decommissioning include the EL research units 2, 3, and 4 at Saclay. Unit 2 operated from 1952 to 1965, Unit 3 from 1957 to 1979, and Unit 4 from 1966 to 1984. Units 2 and 3 currently are at Stage 2 condition. Unit 4, the largest of the three plants at 70 MWe (Units 2 and 3 are rated at 2.8 MWt and 18 MWt, respectively) has not yet undergone decommissioning.

Decommissioning of several other small test reactors, such as the AOE, Nereide, Minerve, and Triton units at Fonteney, and the Peggy, Cesar, and Pegase units at Cadarache, has been carried out to Stages 2 or 3 over the past decade. The largest of these was the Pegase reactor (a 35-MWt research reactor), which operated from 1962 to 1975 and has been completely dismantled, leaving its building free for storage uses. Commercial plants Chinon Unit 3 (a 480-MWe GCR which entered service in 1967), and St. Laurent Unit 1 (a 480-MWe GCR which entered service in 1969) also reportedly could soon be shut down. In general, France's policy on reactor decommissioning aims for reasonably rapid progress through Stage 2, at least for reactors where the presence of a containment structure allows for relatively easy long-term storage, with indefinite postponement of total dismantlement.

© NUEXCO 1987

Federal Republic of Germany — In the FRG, one major project is underway and another is scheduled to begin soon. The Niederaichbach reactor, a 100-MWe gas-cooled heavy-water reactor at Karlsruhe, only operated over a period of two years (producing power for less than three weeks), from 1972 to 1974, before technical problems caused its closure. It has been licensed for decommissioning since 1985, and currently is scheduled to reach Stage 2 condition by 1992. The 250-MWe (BWR) Gundremmingen Unit A, owned by Kernkraftwerk RWE-Bayernwerk GmbH (KRB), recently has received its decommissioning license. This unit operated from 1966 to 1977, and was shut down after the owners judged costs of repair and upgrading, following a coolant leak incident, to be uneconomical.

Other units scheduled for decommissioning include Rheinisch-Westfaelisches Elektrizitaetswerk AG's (RWE) 15-MWe BWR located at Kahl (the FRG's first nuclear power plant), and Kernkraftwerk Lippe-EMS GmbH's (KLE) Lingen plant (256-MWe BWR, located at Emsland), which operated from 1968 to 1977. The Karlsruhe multi-purpose research reactor (MZFR, a 58-MWe PWR), in service from 1965 to 1984, also is scheduled for decommissioning. In addition, between 1980 and 1982, the nuclear-powered ship Otto Hahn's reactor was dismantled, with its internal parts placed in safe storage, after ten years of operation.

Japan — Several decommissioning projects are underway or planned in Japan. Because of the need to make the maximum use of land space in Japan, participants in the Long-Term Program on Development and Utilization of Nuclear Energy formulated a policy under which reactors should be completely dismantled as soon after shutdown as practical. This generally means a short period of mothballing or entombment prior to dismantlement, but should mean that reactors are dismantled within 10 to 15 years of shutdown. Several organizations, including the Japan Atomic Energy Research Institute (JAERI) and the Nuclear Power Engineering Test Center, in addition to several of Japan's large industrial companies, are actively developing the necessary

Table 4

PAST DECOMMISSIONING PROJECTS[1]

Reactor	Year Decommissioned	Country	Type	Capacity (Gross MWt)[2]	Stage
Gentilly 1	1985	Canada	CANDU	250(e)	1
EL 3	1986	France	HWR	18	2
Pagase	1978	France	MTR-LW	35	3
Chinon A1	1980	France	GCR	80(e)	1
NS Otto Hahn	1981	FRG	PWR	38	3
BONUS[3]	1970	Puerto Rico	BWR	50	2
Agesta	1975	Sweden	PHWR	80(e)	1
Lucens CNL	1969	Switzerland	GCHWR	30	3
BEPO	1968	UK	Graphite	6(e)	2
CTVR[4]	1968	USA	HWR	65	1
Elk River	1968	USA	BWR	58	3
Hallam	1968	USA	Graphite	256	2
Piqua	1969	USA	Organic	45	2
Pathfinder	1972	USA	BWR	190	1
Saxton	1973	USA	PWR	23	1
Fermi 1	1975	USA	FBR	200	1
Peach Bottom 1	1978	USA	GCR	115	1
SRE[5]	1982	USA	Graphite	30	3

[1] Includes only major projects or projects of interest. List is not exhaustive or all inclusive.

[2] Megawatts of thermal capacity. (e) indicates electrical capacity.

[3] Boiling Nuclear Superheat Reactor

[4] Carolina Virginia Tube Reactor

[5] Sodium Reactor Experimental Facility, California

© NUEXCO 1987

Table 5

NUCLEAR REACTORS AWAITING OR UNDERGOING DECOMMISSIONING

Reactor	Year Started	Year Shut down	Country	Type	Capacity (Gross MWe)[1]
Douglas Point	1968	1982	Canada	CANDU	206
G1 Marcoule	1956	1975	France	GCR	46(t)
G2 Marcoule	1958	1980	France	GCR	45
G3 Marcoule	1959	1983	France	GCR	45
Chinon A2	1965	1984	France	GCR	230
EL-4	1966	1984	France	HWR	70
Rapsodie	1967	1982	France	FBR	40(t)
Karlsruhe	1965	1984	FRG	PWR	58
Gundremmingen	1966	1977	FRG	BWR	250
Lingen	1968	1976	FRG	BWR	256
Niederaichbach	1972	1974	FRG	HWGCR	100
Garigliano	1964	1978	Italy	BWR	160
JRR 3[2]	1962	1983	Japan	HWR	10(t)
JPDR[3]	1963	1976	Japan	BWR	10
Windscale	1962	1981	UK	AGR	33
Shippingport	1957	1982	USA	PWR	72
Dresden 1	1960	1978	USA	BWR	210
Indian Point 1	1962	1974	USA	PWR	257
Humboldt Bay	1963	1976	USA	BWR	65

[1] (t) indicates thermal capacity
[2] Japan Research Reactor
[3] Japan Power Demonstration Reactor

© NUEXCO 1987

technologies, especially those involving robots. Current Japanese policy envisions that technological solutions to handling highly radioactive materials will be available in the late 1990s, about the time that the first large commercial reactors will be shut down.

1. In December 1986, JAERI began decommissioning procedures on the Japan Power Demonstration Reactor (JPDR), a 12.5-MWe (45-90 MWt) BWR located at Tokai-mura. The unit first generated electricity in October 1963, and operated until 1969. Following core modifications, power was doubled, from 45 MWt to 90 MWt, from 1972 to 1976, when the unit was shut down. Planning has been underway since 1981, in two main phases. In the first phase, efforts concentrated on development of dismantling technology and system engineering, and this phase was largely completed by early 1986. Phase 2 involves demonstrating the technology, and will continue until the reactor is completely dismantled in 1991.

This project is the focal point of Japan's research and development into decommissioning technology, including extensive use of robots, and the experimental use of a plasma-arc cutting machine to cut the reactor vessel. The project schedule calls for initial removal of equipment during the spring of 1987, followed by dismantling of the reactor's internal parts in late 1987. In 1988, JAERI will segment and remove the reactor pressure vessel and remaining equipment, and in 1989 will demolish the 1.5- to 3-meter thick concrete containment structure. By 1990, the reactor's primary containment vessel will be removed, leaving the site free for backfill and landscaping in 1991. From beginning development to final release of the land for unrestricted access, the decommissioning process wil! have taken ten years.

2. Japan's first nuclear reactor, JRR Unit 1 (50-KWt BWR), has been mothballed as a monument. JRR Unit 3, a 10-MWt heavy-water moderated reactor, operated for more than 20 years until being shutdown in 1983, and recently was moved, as a complete unit, into a nearby warehouse for long-term storage.

3. Tokai Unit 1, a 159-MWe GCR of the Magnox type owned by Japan Atomic Power Company Ltd., reportedly will be Japan's first commercial unit to be decommissioned. This plant began commercial service in 1966 and is scheduled to be shut down within the next few years.

United Kingdom — In 1981, the United Kingdom Atomic Energy Authority (UKAEA) began decommissioning of the 33-MWe Windscale advanced gas-cooled reactor (AGR), the prototype for the UK's 14 commercial AGRs. Only the reactor itself and the spherical containment structure will be removed; the UKAEA will continue to use the other buildings on site. To date, contractors have removed the machinery from the turbine building, and the UKAEA is making preparations to dismantle the pressure vessel, reactor core and containment

The UKAEA and the engineering firm Strachan & Henshaw are jointly designing a remote-controlled cutting machine that will operate within the reactor vault, first cutting up the reactor's internals, then segmenting the pressure vessel. This phase of the project probably will take place between late 1991 and 1995. In terms of technology development and application, the Windscale project offers several advantages. While is is much smaller than the commercial units, the Windscale unit at least represents the UK's main reactor type, and it operated for 19 years, long enough to achieve radiation levels that approximate what will be found in later, commercial decommissioning projects. At least one of the UK's Magnox reactors is expected to be shut down in the 1990s, and the possibility exists for closure of several others. Eight Magnox units entered service between 1956 and 1958.

USA — In the USA, only four units that produced commercial electricity have been, or currently are being decommissioned.

1. The Elk River, Minnesota reactor (US Atomic Energy Commission, 22-MWe PWR) is the only one to have been completely decontaminated and dismantled. It operated for only four years, 1964 to 1968, and decommissioning was completed in 1974.

2. Peach Bottom Unit 1 (Philadelphia Electric Company, 40-MWe HTGR) entered service in 1967. The plant operated until 1975, when the utility decided close it for decommissioning. It currently is mothballed.

3. Fermi Unit 1 (Detroit Edison, 200-MWt PWR) was mothballed in 1975, after being shut down in 1972.

4. The 60-MWe Shippingport reactor, near Pittsburgh, Pennsylvania, was the USA's first commercial nuclear reactor, and also is the first US reactor to be decommissioned after a relatively long period of operation. The unit is owned by the Department of Energy (DOE) and the Duquesne Light Company. The unit started commercial operation in 1957 and operated until 1982. DOE and General Electric Corporation, the project's Decommissioning Operations Contractor, began decommissioning the unit in 1985, but are using a method that is unlikely to be repeated, particularly for commercial-scale units. After removal and decontamination of the external systems, the contractors will lift the reactor pressure vessel as a unit, and ship it to DOE's Hanford, Washington nuclear reservation for disposal, where it will be buried intact. This method will save about one year, compared to

© NUEXCO 1987

segmentation of the vessel and its internal parts, but unfortunately will provide only limited experience for future projects. The Shippingport project is scheduled for completion by mid-1988.

Thus far, the largest reactor to be decommissioned in the USA has been the 256-MWt Hallam unit in Nebraska, which was entombed in concrete in 1969. Other US reactors awaiting decommissioning include Dresden Unit 1 (Commonwealth Edison, 210-MWe BWR), which operated from 1960 to 1978, Indian Point Unit 1 (Consolidated Edison, 257-MWe PWR), which operated from 1962 to 1974, and the Humboldt Bay Unit 3 reactor (Pacific Gas & Electric, 63-MWe prototype BWR), in service from 1963 to 1976. PG&E plans to dismantle the Humboldt Bay plant in 2015, after 30 years of safe storage.

Both the Indian Point and Dresden plants are located at sites where other, newer reactors also are operating. Their situation typifies a dilemma that will be increasingly common as older plants are retired from operation. The probable solution in many cases will be to mothball or place those plants in Stage 1 condition, until the other reactors occupying the site also are permanently shut down.

Nuclear Plant Life Extension

A crucial factor in estimating the number of plants to be decommissioned in years to come is the possibility of gaining extensions for plants' operating licenses. There will be substantial economic pressure (and incentive) to maximize returns on generating plants, especially since investment in these plants will have been fully amortized as they approach the end of their operating license periods. Without extensions on plants' operating license periods, replacing the capacity lost by permanent shutdown — up to 50 gigawatts between 2002 and 2008 in the USA alone — will put an enormous financial burden on the electric power infrastructure.

In the USA, nuclear power plant design lifetimes generally are based on forty calendar years of operation, which is the maximum period of time allowed under NRC licenses. Presently, no rules prohibit application for an extension of this license. Prior to 1982, the NRC license period began with the issuance of the plant's construction permit; since 1982, the licensing period has begun with issuance of the plant's operating license. Since the construction time represents a significant part of the license period, and one which is highly variable from plant to plant, one path to life extension for plants licensed before 1982 is through recovery of licensed operating time lost during the construction process. Since 1985, the NRC has allowed requests by utilities to begin the license period retroactively from the date of low-power operation instead of the date the construction permit was issued. At least 14 nuclear units have thus far had their licenses extended, and a number of others have applications pending.

Another possible approach that would extend licensed operating time involves gaining back time lost through outages, whether for refueling or repair. Assuming a forty-year operating lifetime, an average availability factor of 75 percent would mean that ten years of operating time would be lost to outages, effectively reducing the operating lifetime by 25 percent, to 30 full-power years. While it seems relatively easy and straightforward to compensate for the construction period of a plant, assessing outage time is much more complicated. Transient reactor states — startups, shutdowns, scrams occurring under power, and other unusual events — may cause fatigue many times greater than that which occurs under steady operating conditions. Documenting plant condition under all transient states, in order to describe all outages for the purpose of recovering license time, could require considerably greater recordkeeping than is commonly the norm.

Even assuming that the NRC occasionally or even routinely grants license extensions, many economic factors govern whether a utility is justified in undertaking the extensive refurbishing and replacement of components that would allow, for example, a twenty-year license extension. Obviously, the investment/return balance must weigh in favor of the necessary investment, and that investment could conceivably require extensive upgrading within a then-tighter regulatory environment. Estimates of such reconditioning suggest costs between $100 million and $1 billion. Replacement of the reactor pressure vessel, for example, could cost up to $150 million. The potential return from twenty years of additional electricity generation could, however, be several times that amount.

It is impossible to predict the political, environmental, or regulatory climate that could affect approval for extensions in plant operating lifetimes in the next century. However, if even half of the plants whose current licenses expire between 2000 and 2010 can secure extensions, the effect on decommissioning schedules will be substantial.

Political and Social Factors

Plant age and condition naturally are primary factors in determining whether a reactor should be retired and decommissioned. Political and social considerations, however, are potentially extremely important variables that could result in early shutdowns not based on technical or licensing reasons.

© NUEXCO 1987

After accidents at Three Mile Island in 1978 and Chernobyl in 1986, extensive political debate focused on the desirability of nuclear power and its potential threat to public safety. These events led to new regulatory and legal initiatives and scrutiny that continues today.

The countries most affected by political and social opposition to nuclear power are the Federal Republic of Germany (FRG), Sweden, and Italy. In the FRG, the Green Party, in occasional partnership with the Social Democratic Party (SPD), often has stated its desire to close immediately all nuclear power stations in that country. Although the SPD-Green alliance did not succeed in taking control of the federal government in the January 1987 elections, their anti-nuclear political position did raise the issue of near-term decommissioning of existing plants, and, along with the accident at Chernobyl, provoked several serious economic studies into the feasibility of eliminating nuclear power in the FRG. The SPD's pre-election stand against nuclear energy called for full shutdown of all 18 of the FRG's nuclear plants by 1997.

Italy's three operational nuclear units face an even more uncertain future, and at present, none of those reactors are operating. The Latina and Caorso units are shut down for maintenance, although anti-nuclear public sentiment may be partially or wholly responsible for their not being restarted, and the Trino Vercellese plant is out of service for refueling. Trino's operating license expires in 1990, and there is a strong possibility that the unit will be retired at that time. The Latina and Trino reactors entered commercial service in 1963 and 1964, respectively, while Caorso began operating in late 1981. Italy's Garigliano reactor, a 160-MWe BWR that operated from 1964 to 1978, reportedly may soon begin the decommissioning process.

Swedish law has, since 1981, required the country to withdraw from nuclear power by 2010. Prime minister Ingvar Carlsson, however, has stated his intention to accelerate the process by closing nuclear plants in 1993 and 1996. No specifics have been mentioned, but over the last several years anti-nuclear protests repeatedly have targeted the Barseback station, which is only about 30 km from Copenhagen. This unit is the most likely candidate for early closure if it does occur. Whether any plants actually are closed ahead of schedule probably depends to a considerable extent on Swedish public opinion for or against nuclear power in the next few years. Political rhetoric aside, Sweden's nuclear units play an extremely important part in its electric power infrastructure. Since no economically acceptable alternatives to those nuclear plants are readily available, early plant closure appears unlikely at this time.

While it is unlikely that public opinion in the USA will actually force early nuclear plant closures, effective opposition to nuclear power could have a similar effect by making upgrading or reconditioning of marginal facilities not worth the cost. Tighter NRC and environmental regulations, and costly legal challenges over a wide range of issues could influence some utilities to simply close their older, more maintenance-intensive nuclear plants, perhaps even before their operating licenses expire. Minor, but costly, incidents could become major economic obstacles.

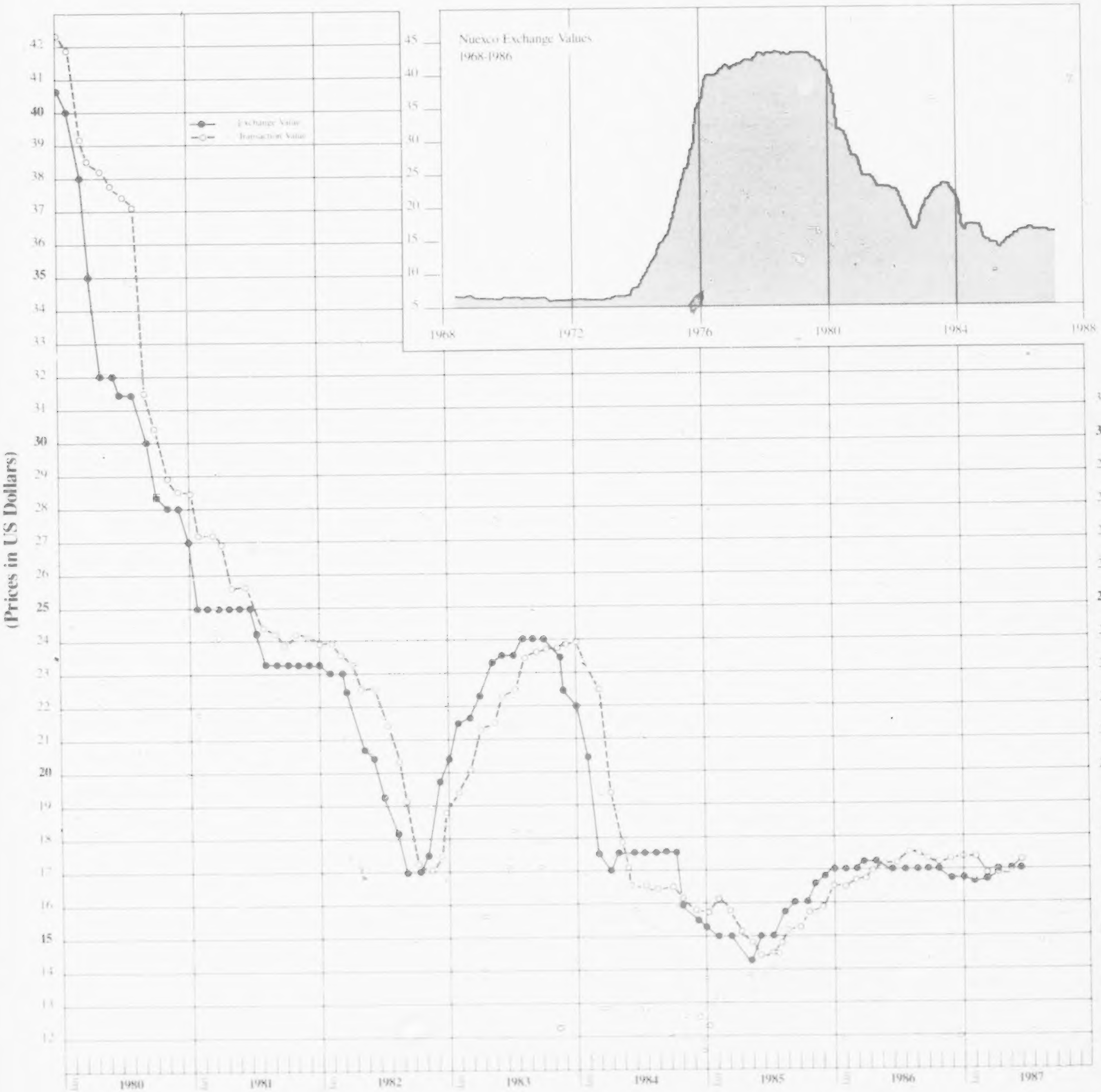
The nuclear power industry has not yet really confronted the public, and their political representatives, with the choices required by multiple nuclear plant decommissionings. Nor is the public really aware of the costs and technical challenges associated with fully dismantling even one large commercial reactor, much less tens or hundreds of them. Nuclear utility managers are accustomed to thinking in terms of decades — for plant construction, for fuel procurement contracts, and for return on capital investments. It may be much easier, then, for utility personnel to plan for decommissioning over the long term, meaning up to a century, than for the public to accept such a timeframe, especially where storing a large, highly radioactive plant is concerned. It would not be unrealistic to expect a strong clash of intentions where, for example, a utility presents its plans to the public to impound its retired reactor or reactors for 50 or even 100 years before attempting their disposal.

Conclusion

Worldwide, decommissioning of commercial nuclear reactors is just beginning. In the decades to come, however, the permanent shutdown of numerous commercial nuclear power plants will require extensive development of dismantling technology, as well as the cooperation (and education) of the public, who will have to accept the existence of reactors placed in various degrees of safe storage for long periods of time. Experience being gained today, and over the next few years in France, the FRG, Japan, the UK and the USA will provide the basis for safe and economic future decommissioning projects.

NUEXCO

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	**17.00**							

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	**17.20**							

© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	**1.80**							

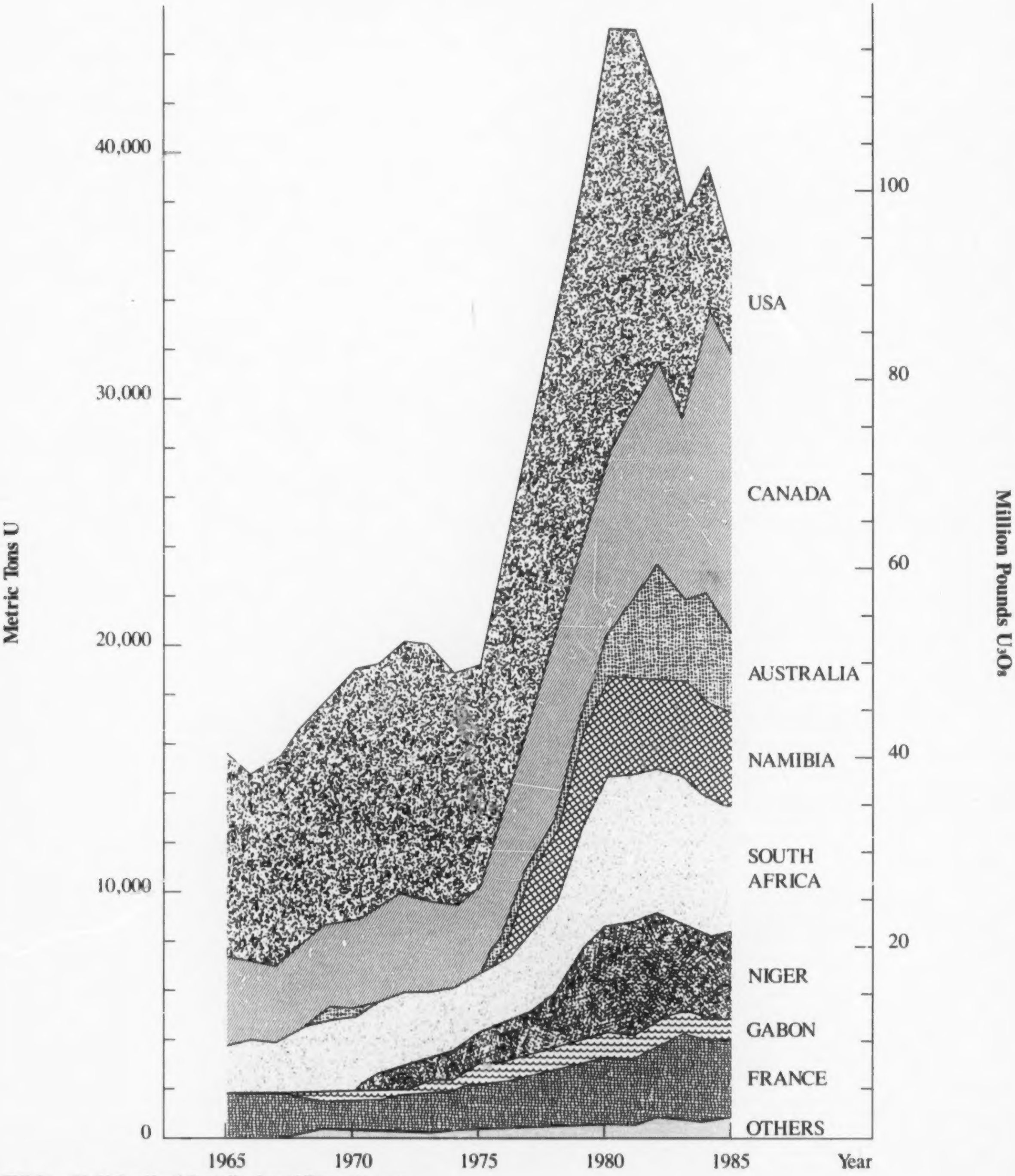
HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	**47.75**							

© NUEXCO 1987

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium (\$/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

©NUEXCO 1987

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

GOVERNMENT STATISTICS

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1976 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]	133.6	100.0	—
FY86 Avg.[7]	—	105.0	—
Jan 1986	—	109.6	210.0
Feb 1986	—	108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986	—	94.3	210.5
May 1986	—	93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986	—	98.1	215.3
Aug 1986	—	98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986	—	106.2	215.4
Nov 1986	—	105.2	215.6
Dec 1986	161.5	105.5	215.6
Jan 1987	—	106.4	215.9
Feb 1987	—	109.2	216.5

P = Preliminary   R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5] Annual averages prior to 1979 reflect index base no longer in use.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

[7] Annual averages are for financial year ending June 30.

©NUEXCO 1987

CANADA

GOVERNMENT STATISTICS

		Wage-earner Data: Average Hourly Earnings (C$)[2]					
	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan 1987	120.0	19.52	16.84R	16.07R	13.06R	12.56R	12.95R
Feb 1987	119.8	20.33	17.15	16.09	13.01	12.66	13.18
Mar 1987	120.3	20.04P	17.06P	16.06P	12.85P	12.69P	13.06P
Apr 1987	120.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

©NUEXCO 1987

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.70	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	—	—
Mar	1987	88.17	197.1	255.0	239.6	—	—
Apr	1987	—	—	258.2	—	—	—

P = Preliminary   R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

©NUEXCO 1987

UNITED STATES

	Producer Price Index[1]				Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6	298.4	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.16	12.20	9.85
Jan 1987	313.6	300.9	333.1	—	12.80	13.10	12.17	9.86
Feb 1987	315.7	302.7	334.4	—	12.81R	12.95R	12.20	9.86R
Mar 1987	315.8	302.8	335.9	116.2	12.89P	12.90P	12.23R	9.85R
Apr 1987	317.4	305.1	337.7	—	—	—	12.32P	9.87P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan

Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. Von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

B6800-1A-
7/10/87

NUEXCO

Monthly Report

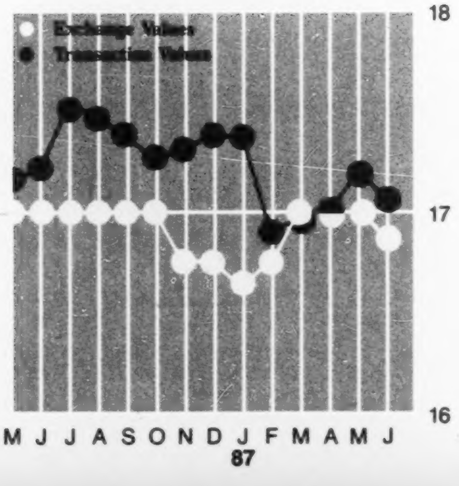
July 1987 Number 227

Ten New Reactors Have Entered Service This Year 13

Politics and Economics Affecting The Canadian Uranium Industry 16

Enrichment Blending May Save SWU Costs 23

Decommissioning of Nuclear Plants, Part 2 27



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

CHIEF EXECUTIVE OFFICER — Charles H. Peterson

NUEXCO TRADING CORPORATION

President	Earl E. Hoellen, Jr.
Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

NUEXCO INFORMATION SERVICES

President	R. Gene Clark

Support Services

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

Hans W. Vogt
(Switzerland)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 227
(All data as of June 30, 1987)

Exchange Value
\$16.90, down \$0.10

The **Exchange Value** is **\$16.90** per pound U_3O_8, down \$0.10 since last month.

UF_6 Value
\$47.75, unchanged

The **UF_6 Value** is **\$47.75** per kilogram U as UF_6, unchanged since last month.

Transactions

Twelve recent natural uranium sales are reported, involving **3.9 million** pounds equivalent U_3O_8. Eight of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value.

Supply-Demand Ratio
Increased to 3.7:1

Active spot and near-term **uranium supply** amounts to **3.7 million** pounds U_3O_8 equivalent, down 400 thousand pounds since last month. Active spot and near-term **uranium demand** totals **1.0 million** pounds, down 375 thousand pounds from last month. The spot and near-term **supply-demand ratio** increased to **3.7 to 1**.

Transaction Value
\$17.10, down \$0.10

The **Transaction Value** is **\$17.10** per pound U_3O_8, **down \$0.10** since last month. The calculation includes 13 transactions involving a total of 3.5 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate
unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value
\$1.80, unchanged

The **Conversion Value** is **\$1.80** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 300 thousand pounds U as UF_6. No active demand is listed this month. Two secondary market conversion transactions are reported.

SWU Value for
delivery within
one year: \$73,
down \$2.00

The **SWU Value** at .3 tails and for delivery within one year is **\$73** per SWU, down \$2.00 since last month. No secondary market SWU transactions are reported.

* * *

Recent Developments

So far this year, ten new reactors have entered commercial operation — four in France, three in the USA, and one each in the Federal Republic of Germany, Japan, and South Korea, totaling almost 10,000 MWe new capacity.

Analysis and
Commentary

Several economic and political issues affect the Canadian uranium industry, including bilateral trade discussions between the US and Canada, and political trends that could result in the election of parties potentially hostile to uranium production. This article looks at those issues, as well as describing the way in which the Canadian government interacts with commercial uranium transactions.

Analysis and
Commentary

Enrichment blending is an alternative to upgrading enriched product to achieve desired enrichment levels. As such, it can offer a way to save costs and time when compared to normal upgrading techniques.

Basic Considerations

Decommissioning nuclear plants involves significant radiation hazards, and requires methods different than those involved in the decommissioning of other types of power plants. This second part of a two-part article examines the radiological environment of shutdown nuclear plants, the technology required to dismantle them, and the estimated costs of fully decommissioning large-scale, commercial reactors.

This Executive Summary may be reproduced for internal distribution.

©NUEXCO 1987

NUEXCO

NUEXCO REPORT 227 FIGURES OF THE MONTH (June 30, 1987)	This Month (Report 227)	Last Month (Report 226)	12 Months Ago (Report 215)
Exchange Value[1]	16.90	17.00	17.00
Transaction Value[1]	17.10	17.20	17.20
UF_6 Value[2]	47.75	47.75	48.25
Loan Rate[3]	3%	3%	4%
Conversion Value[4]	1.80	1.80	1.80
Near-Term Uranium Supply[5]	3.7	4.1	4.1
Near-Term Uranium Demand[6]	1.0	1.4	2.1
Near-Term Supply-Demand Ratio	3.7	3.0	2.0
Recent Uranium Sales:			
Number of Transactions[7]	12	6	4
Quantity of Material[8]	3.9	5.3	0.6
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	73	75	78
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	441	450	457
3.0 w/o U_{235}	563	575	585
3.5 w/o U_{235}	691	702	715
4.0 w/o U_{235}	818	831	847

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (226)

Section	Topic	Page
Analysis and Commentary	The Secondary SWU Market in the 1990s	13
Japan	Utilities Conclude Annual NUFCOR Delivery Price	19
Basic Considerations	Decommissioning of Nuclear Plants, Part I	23
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in May 1987	1
	Enriched Uranium and SWUs Pricing in May 1987	3

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

July 1987 No. 227

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA

Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

RECENT DEVELOPMENTS

Mid-Year Reactor Progress Update 13

ANALYSIS AND COMMENTARY

Economic and Political Issues Affecting the Canadian Uranium Industry 16

ANALYSIS AND COMMENTARY

Enrichment Blending 23

BASIC CONSIDERATIONS

Decommissioning of Nuclear Plants, Part 2 27

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 36
Historical Exchange Values and Transaction Values 37
Historical Conversion Values and UF_6 Values 38
Graph of World Uranium Production 39
US Uranium Marketing Activities Statistics 40
Volume and Price of Uranium Deliveries to the European Community 41

GOVERNMENT STATISTICS

Australia 42
Canada 43
South Africa 44
United States 45

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

NUEXCO

To Our Readers

We are pleased to announce that Charles H. Peterson will be joining Nuexco, effective August 1, 1987, as President and Chief Executive Officer. Mr. Peterson comes to Nuexco from Cogema, Inc. where he has been the U.S. Vice President. His years of experience in the nuclear power field and his dynamic personality will bring additional strong industry-experienced leadership to Nuexco and permit us to build on our present service capabilities.

Chuck, raised in Pueblo, Colorado, was appointed to the U.S. Naval Academy in 1956 and served in the U.S. Navy for 13 years, primarily as an engineer in the construction and operation of nuclear powered submarines. Subsequently, he earned graduate degrees in Business Administration and Law at Stanford University. Prior to joining Cogema, he had extensive experience in the Nuclear Power and Aerospace Groups of General Electric Company.

At Cogema, Chuck has been actively engaged in entry of Cogema into the U.S. enrichment market and the expansion of the French nuclear industry into the U.S. market for nuclear products and services. As President and Chief Executive Officer, he will have general managerial and supervisory responsibilities for Nuexco activities, including the establishment of policies, as well as participation in overall strategy development for the individual Nuexco divisions and corporations, among which are Nuexco Trading Corporation headed by Earl Hoellen as President and Nuexco Information Services headed by Gene Clark as President.

Oren L. Benton will remain as Chairman of the Board of Directors of Nuexco, devoting his time primarily to overall organizational planning and new business development for Nuexco and its affiliated entities. The continuing growth of Nuexco will allow us to increase the scope of the services we provide to our customers and to provide our traditional services with greater resources and increased flexibility. Enclosed with this month's Report is a brochure describing some of Nuexco's service capabilities.

* * *

In an effort to maintain and improve the high level of service which has always been Nuexco's goal, we encourage you to let us know your views and opinions concerning Nuexco's publication services. We are asking for this input in the form of a questionnaire which will soon be mailed to each subscriber. In addition, we will also be contacting some customers by telephone. We hope that you will take a few moments to answer the survey so that we can continue to meet the needs of our most valued asset — you, the customer.

© NUEXCO 1987

PRICING

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of June 30, 1987)

The **Exchange Value** is **$16.90** per pound U_3O_8, down $0.10 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **3,680,000** pounds U_3O_8 equivalent, down 400,000 pounds since last month. The corresponding figure for **active demand** is **1,000,000** pounds, down 375,000 pounds. The spot and near-term **supply-demand ratio** increased to **3.7 to 1.**

The *Current Market Data* section of this Report lists twelve natural uranium sales, totaling 3.9 million pounds U_3O_8 equivalent. US-origin uranium is commanding a premium (relative to the Exchange Value) of $0.60 per pound U_3O_8 (down $0.30) in the form of concentrates, and $1.75 per kilogram U (down $0.50) in the form of UF_6.

The **Transaction Value** is **$17.10** per pound U_3O_8, down $0.10 since last month. The calculation extends over a 3-month period and includes 13 transactions involving 3.5 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.75** per kilogram U in UF_6, unchanged since last month. Three transactions involving UF_6 are reported, totaling approximately 400,000 pounds equivalent U_3O_8. Demand for UF_6 remains weak, with only one major buyer in the market.

The **Conversion Value** is **$1.80** per pound U as UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 300,000 pounds U as UF_6. No active demand is reported this month. Two secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value declined $0.10 this month to $16.90 in a fairly active spot and near-term market for natural uranium. Although little actual price movement has occurred in the market recently, transaction evidence accumulated over the past two months indicated a slight downward correction in the Exchange Value. Seven spot concentrate sales are reported, involving approximately 1.5 million pounds U_3O_8. One US utility bought a substantial quantity of non-US-origin material for near-term delivery, while other entities bought smaller amounts, largely as discretionary purchases. Two long-term sales also are reported, totaling approximately 1.9 million pounds U_3O_8, both to European utilities.

The fragmentation that has characterized the uranium market, based on material origin and the related factors that make origin significant, appears to be diminishing. The US Tenth Circuit Court of Appeals has not yet ruled in the US Producers vs. DOE lawsuit, and most US utilities have used the ten months since the appeal was heard to maximize the amount of US-origin material held in inventory. Activity in the swap market is at its lowest point since Judge Carrigan ruled in June 1986 on Counts I, III, IV, and V of the lawsuit (the ruling was stayed pending appeal in September 1987), and recent attempts to make US-origin swaps have found no buyers at any price. Demand for US-origin continues to decline and, with it, the premium (relative to the Exchange Value) for US-origin, now $0.60 (down $0.30) per pound U_3O_8. With much of their natural uranium inventories already converted to US origin, and lacking any imperative from the courts, most US utilities see little or no reason to pay a premium for US-origin. The little demand for US-origin is highly discretionary and those buyers have been able to wait for cheaper US-origin material to become available.

Although five of the transactions reported this month involved US-origin material, the individual quantities involved were not large, and only one of the sales was made to a utility; the others were made to traders or to producers. The majority of US producers still are unwilling to offer US-mine-origin uranium at prices near the Exchange Value plus the US premium, and continue to await a decision by the Appellate Court that could result in higher prices. However, the current lack of demand for US-origin has created a buyers' market.

There still are substantial quantities of southern and central African uranium available to buyers not constrained by origin. As Canadian U_3O_8 has become less available, African uranium has increasingly come to dominate the spot market, and there are indications that buyers, particularly of large quantities, would find very attractive prices.

The UF_6 Value remained unchanged at $47.75. Three transactions involving UF_6 are reported this month, totaling approximately 400,000 pounds U equivalent. The market for UF_6 remains weak, with only two sellers and only one non-discretionary buyer in the market for a substantial quantity of material. The premium (relative to the UF_6 Value) for US-origin UF_6 declined $0.50 to $1.75 per kgU, following the decline of the US premium for U_3O_8.

* * *

©NUEXCO 1987

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported. While some loan opportunities exist, most potential transactions are uneconomic because of the security requirements imposed by potential lenders.

* * *

The Conversion Value is unchanged since last month at $1.80. Two conversion transactions are reported, but the secondary market for conversion services remains relatively inactive. Prices for conversion services in Europe continue to be higher than in the USA. Supply of secondary market services has declined slightly since last month, and what little demand does exist is largely discretionary as to timing.

ENRICHED URANIUM AND SWU

The SWU Value declined to $73 per SWU this month. No SWU transactions are reported in the *Current Market Data* section of the Report this month. Again during June, weak demand caused a slight downward price pressure on the secondary SWU market, with only discretionary buyers in the market for SWU. One seller of a large quantity of SWU, part of whose inventory allegedly has been offered by DOE at $75 per SWU, finally entered the market during June. DOE's role in selling this SWU is controversial at best, and the outcome of its efforts to sell on the secondary market will be closely watched by many market participants. Techsnabexport (USSR) SWU continues to sell at prices below $70.

©NUEXCO 1987

CURRENT MARKET DATA

June 30, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**\$16.90**/lb. U_3O_8	3,680	1,000
UF_6 VALUE	**\$47.75**/kgU		
CONVERSION VALUE	**\$1.80**/lb. U as UF_6	300	—
SWU VALUE 0.3 tails assay; delivery within one year	**\$73**/SWU		
LOAN RATE	**3%**/annum	1,000	—

	\$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.10**	3.5	13	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (June 30, 1987)	Last Month (May 31, 1987)	12 Months Ago (June 30, 1986)	This Month (June 30, 1987)	Last Month (May 31, 1987)	12 Months Ago (June 30, 1986)
Australia (dollar)	23.43	23.84	25.35	60.92	61.97	65.92
Belgium (comm. franc)	640.15	640.30	765.08	1,664	1,665	1,989
Canada (dollar)	22.53	22.84	23.60	58.58	59.37	61.36
EEC (ecu)	14.91	14.90	17.52	38.77	38.75	45.56
Finland (markka)	75.21	74.79	87.13	195.53	194.44	226.53
France (franc)	103.11	102.97	119.30	268.07	267.69	310.15
FRG (mark)	30.90	30.82	37.43	80.34	80.12	97.31
Italy (lira)	22,411	22,269	25,703	58,263	57,894	66,822
Japan (yen)	2,478	2,433	2,810	6,443	6,326	7,305
Netherlands (guilder)	34.82	34.76	42.12	90.53	90.36	109.50
South Africa (rand)	34.53	34.34	42.29	89.76	89.29	109.94
Spain (peseta)	2,415	2,151	2,399	6,278	5,591	6,238
Sweden (krona)	107.92	107.59	121.26	280.56	279.72	317.24
Switzerland (franc)	25.68	25.55	30.63	66.76	66.43	79.62
UK (pound)	10.56	10.43	11.10	27.45	27.11	28.86
US (dollar)	16.90	17.00	17.00	43.94	44.20	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (June 30, 1987)	Last Month (May 31, 1987)	12 Months Ago (June 30, 1986)	This Month (June 30, 1987)	Last Month (May 31, 1987)	12 Months Ago (June 30, 1986)
Australia (dollar)	23.71	24.12	25.65	61.64	67.70	66.69
Belgium (comm. franc)	647.73	647.83	774.08	1,684	1,684	2,012
Canada (dollar)	22.80	23.11	23.88	59.27	60.07	62.08
EEC (ecu)	15.09	15.08	17.73	39.23	39.20	46.10
Finland (markka)	76.10	75.67	88.16	197.85	196.73	229.20
France (franc)	104.33	104.18	120.70	271.24	270.84	313.80
FRG (mark)	31.27	31.18	37.87	81.29	81.07	98.45
Italy (lira)	22,676	22,531	26,005	58,953	58,575	67,608
Japan (yen)	2,508	2,462	2,843	6,519	6,401	7,391
Netherlands (guilder)	35.24	35.17	42.62	91.61	91.43	110.79
South Africa (rand)	34.93	34.75	42.79	90.82	90.34	111.23
Spain (peseta)	2,444	2,176	2,428	6,353	5,657	6,311
Sweden (krona)	109.20	108.86	122.68	283.88	283.01	318.95
Switzerland (franc)	25.98	25.85	30.99	67.55	67.21	80.56
UK (pound)	10.68	10.55	11.23	27.78	27.43	29.20
US (dollar)	17.10	17.20	17.20	44.46	44.72	44.72

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on June 30, 1987.

© NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF$_6$			per kg. U as UF$_6$		
Country (currency)	**This Month (June 30, 1987)**	**Last Month (May 31, 1987)**	**12 Months Ago (June 30, 1986)**	**This Month (June 30, 1987)**	**Last Month (May 31, 1987)**	**12 Months Ago (June 30, 1986)**
Australia (dollar)	2.50	2.52	2.68	5.50	5.56	5.92
Belgium (comm. franc)	68.18	67.80	81.01	150.31	149.47	178.59
Canada (dollar)	2.40	2.42	2.50	5.29	5.33	5.51
EEC (ecu)	1.59	1.58	1.86	3.50	3.48	4.09
Finland (markka)	8.01	7.92	9.23	17.66	17.46	20.34
France (franc)	10.98	10.90	12.63	24.21	24.04	27.85
FRG (mark)	3.29	3.26	3.96	7.26	7.19	8.74
Italy (lira)	2,387	2,358	2,721	5,262	5,198	6,000
Japan (yen)	263.97	257.66	297.52	581.95	568.04	655.92
Netherlands (guilder)	3.71	3.68	4.46	8.18	8.11	9.83
South Africa (rand)	3.68	3.64	4.48	8.11	8.02	9.87
Spain (peseta)	257.22	227.70	254.06	567.06	502.00	560.10
Sweden (krona)	11.49	11.39	12.84	25.34	25.12	28.30
Switzerland (franc)	2.74	2.71	3.24	6.03	5.96	7.15
UK (pound)	1.12	1.10	1.18	2.48	2.43	2.59
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF$_6$ VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU VALUE delivery within one year (June 30, 1987)**	**UF$_6$ Value per kg.U in UF$_6$ This Month (June 30, 1987)**	**UF$_6$ Value per kg.U in UF$_6$ Last Month (May 31, 1987)**
Australia (dollar)	101.22	66.20	66.95
Belgium (comm. franc)	2,765	1,809	1,798
Canada (dollar)	97.33	63.66	64.14
EEC (ecu)	64.41	42.13	41.86
Finland (markka)	324.88	212.50	210.07
France (franc)	445.39	291.33	289.21
FRG (mark)	133.48	87.31	86.56
Italy (lira)	96,804	63,321	62,549
Japan (yen)	10,705	7,002	6,835
Netherlands (guilder)	150.42	98.39	97.62
South Africa (rand)	149.13	97.54	96.46
Spain (peseta)	10,432	6,823	6,040
Sweden (krona)	466.16	304.91	302.21
Switzerland (franc)	110.93	72.55	71.77
UK (pound)	45.61	29.83	29.29
US (dollar)	73.00	47.75	47.75

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on June 30, 1987.

©NUEXCO 1987

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
4061	1987	101-300	101	Trader	Utility	
4067	1987	101-300	100	Producer	Utility	UF_6
4082	1987	50-100	R[5]	R[5]	Utility	UF_6
4085	1987	301-600	100	Producer	Utility	
4086	1988	101-300	109	Producer	Utility	US-origin
4087	1987-90	601-1,000	R[5]	Producer	Utility	
4091	1987	less than 50	106	Producer	Trader	US-origin
4099	1987	50-100	104	Producer	Producer	US-origin
4103	1987	101-300	104	Trader	Producer	US-origin
4104	1987	101-300	98	Producer	Trader	US-origin UF_6
4106	1987	301-600	100	Fabricator	Utility	
4107	1988-93	1,001-1,500	R[5]	Producer	Utility	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.3% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
4095	1987	101-300	less than 103	R[5]	Utility	
4101	1987	101-300	R[5]	Trader	Utility	

©NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(June 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2335*	270	—	
2764*	300	—	
2893A	720	—	UF_6
2989	40	—	
2996	200	500 per year	1988-90
3023	400	500	UF_6
3121	1,000	—	
3238	500	—	
3244	250	300 per year	1988-93
2263	—	400 per year	1989 on
2781	—	400 per year	1988-95
3123	—	2,000	1988
3171	—	200 per year	1988-92
TOTAL:	3,680		
INACTIVE			
2297	100	100 per year	1988-89
2933*	300	300 per year	1988-90
2967	1,000	—	
3168	50	100 per year	1988-92
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
3230*		500	1988 on-
TOTAL:	1,450		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2336, 3166, 3316.

©NUEXCO 1987

URANIUM DEMAND
(June 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2911	65	—	UF_6
3220*	500	—	U_3O_8 or UF_6
3251*	260	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3120	—	1,000 per year	1988-91
3137	—	4,800 per year	1993-97
3149	—	300	1989
3193	—	700 per year	1989,91,94,96
TOTAL:	1,000		
INACTIVE			
2798	150	—	
2984	260	—	U_3O_8 and UF_6
3149	300	—	1989
3192*	50	—	
3249*	150	—	
TOTAL:	910		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 3141, 3175, 3191, 3216.

©NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(June 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF$_6$) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
2764B	300	—	
TOTAL:	300		
Available for Sale: INACTIVE			
2859	750	750	
3165	330	—	
TOTAL:	1,080		
Inquiries to Purchase: INACTIVE			
2833	440	—	
TOTAL:	440		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: 2833, 2988, 2997.

©NUEXCO 1987

LOAN SUPPLY AND DEMAND
(June 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
TOTAL:	1,000		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(June 30, 1987)

	Delivery Period[1] (Thousands of SWUs)		
Nuexco Project Number	Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2969*	200	—	1988
3173	45	—	1987
3291*	360	—	1987
TOTAL:	605		
INACTIVE			
2571	50	—	1987
3213	150	—	
TOTAL:	205		
Inquiries to Purchase:			
ACTIVE			
2999	50	100	1988
TOTAL:	50		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 3159, 3322.

©NUEXCO 1987

MID-YEAR REACTOR PROGRAM UPDATE

So far this year, ten reactors, totaling nearly 10,000 MWe capacity, have entered commercial service in five countries. Four new reactors have begun operations in France, adding over 3,400 MWe to the French nuclear capacity, and two others are scheduled to begin operating by the end of this year, adding another 2,600 MWe of new capacity, for a total increase of 6,000 MWe by the end of the year. In the Federal Republic of Germany, Japan and South Korea, single units have gone into operation.

In the USA, three reactors have begun commercial operation and eight others are scheduled to do so by the end of 1987. If all those units do go on line by the end of the year, nearly 11,000 MWe (net) of nuclear capacity will be added to the US nuclear operating base in 1987, somewhat more than the 1985 and 1986 figures of 9,000 and 9,600 MWe, respectively.

Table 1

NUCLEAR UNITS PROGRESS THROUGH JUNE 1987

Unit	Utility	Country	MWe Net	Type	COD
Entered Commercial Operation					
Cattenom 1	Electricite de France	France	1,265	PWR	April 1987
Chinon B3	Electricite de France	France	870	PWR	March 1987
Flamanville 2	Electricite de France	France	1,290	PWR	March 1987
Saint Alban 2	Electricite de France	France	1,300	PWR	March 1987
THTR-300	VEW[1]	FRG	300	THTR	June 1987
Tsuruga 2	JAPC[2]	Japan	1,160	PWR	Feb 1987
KNU-8	KEPCO[3]	Korea	900	PWR	June 1987
Byron 2	Commonwealth Edison	USA	1,120	PWR	April 1987
Shearon Harris	Carolina Power & Light	USA	900	PWR	May 1987
Vogtle 1	Georgia Power	USA	1,100	PWR	May 1987
Undergoing Fuel Loading or Low-Power Testing					
Bruce 8	Ontario Hydro	Canada	750	CANDU	July 1987
Cattenom 2	Electricite de France	France	1,265	PWR	July 1987
Chinon B4	Electricite de France	France	870	PWR	Aug 1987
Beaver Valley 2	Duquesne Light Company	USA	833	PWR	4th/Q 1987
Braidwood 1	Commonwealth Edison	USA	1,120	PWR	Sept 1987
Clinton 1	Illinois Power	USA	933	BWR	April 1987
Fermi 2	Detroit Edison	USA	1,093	BWR	Sept 1987
Nine Mile Point 2	Niagara Mohawk	USA	1,080	BWR	4th/Q 1987
Palo Verde 3	Arizona Public Service	USA	1,221	PWR	Oct 1987
Perry 1	Cleveland Electric Illuminating	USA	1,205	BWR	3rd/Q 1987
South Texas Project 1	Houston Lighting & Power	USA	1,250	PWR	Dec 1987

---

[1] Vereinigte Electrizitaetswerke Westfalen AG.

[2] Japan Atomic Power Company.

[3] Korea Electric Power Company.

RECENT DEVELOPMENTS

Canada

Ontario Hydro's Bruce Unit 8, a 750-MWe Candu reactor, currently is undergoing commissioning and testing. The unit is scheduled to be connected to the grid in July or August 1987. Pickering Units 1 and 2, which have been shut down for the past two years for retubing, are scheduled to resume operation in July and December 1987, respectively.

France

Four new units have entered commercial service in France so far in 1987. In March, Saint Alban Unit 2, Flamanville Unit 2 (1,300-MWe PWRs) and Chinon Unit B-3 began operation. The Chinon plant (870-MWe PWR) was first connected to the grid in October 1986, and is the 33rd of the 900-MWe series in France. And in April, Cattenom Unit 1 (1,265-MWe PWR) entered commercial operation.

Two other 1,300-MWe units are scheduled for operation later in 1987. Cattenom Unit 2 began loading fuel at the end of April and is expected to begin service in July. Fuel loading at Belleville Unit 1, scheduled to begin in June, has been postponed because of the unit's failure to pass containment leak tests. The unit was expected to begin commercial operation in August, but is tentatively scheduled to start before the end of the year.

Federal Republic of Germany

The 300-MWe Thorium High-Temperature Reactor (THTR-300), owned by a consortium of utilities and other German companies, has entered commercial operation. The unit generated over one billion kilowatt-hours during testing and trials. RWE's (Rheinisch-Westfaelisches Elektrizitaetswerk AG) Muelheim-Kaerlich 1,227-MWe PWR also has received its operating license. RWE expects to start the unit by the end of July 1987.

Japan

Japan Atomic Power Company's Tsuruga Unit 2 (1,160-MWe PWR) entered commercial operation in February 1987. Construction started on the unit in April 1982. Two other units, Chubu Electric Power Company's Hamaoka Unit 3 (1,100-MWe BWR) and Tokyo Electric Power Company's Fukushima Unit II-4 (1,100-MWe BWR) are scheduled to enter service later in the year, bringing Japan's total nuclear generating capacity to 25,850 MWe.

South Korea

Korea Nuclear Unit 8 (KNU-8), a 900-MWe PWR, entered service in June 1987. With the addition of this unit, Korea's nuclear plants contribute over 30 percent of the country's total rated electrical capacity.

USA

Vogtle Unit 1, Georgia Power Company's 1,100-MWe PWR entered commercial operation May 31. Construction of the Westinghouse unit began in 1974. Total cost of both Units 1 and 2 (Unit 2 is scheduled to begin operation in 1988) is nearly $9 billion.

Carolina Power & Light Company's Shearon Harris Unit 1 (900-MWe Westinghouse PWR) began commercial operation at the beginning of May 1987. The unit received its full power license in January, and first reached full power on April 21. The plant's construction cost $3.8 billion. Three other units originally planned for the site were canceled several years ago.

Commonwealth Edison's Byron Unit 2 (1,120-MWe PWR) entered commercial service on April 11, almost two months ahead of schedule. The company's Braidwood Unit 1 (1,120-MWe Westinghouse PWR) received a full power license in June, and currently is undergoing testing. The utility expects the unit to begin commercial operation in September 1987.

Clinton Unit 1, Illinois Power Company's 933-MWe General Electric BWR, was connected to the power grid on April 24. The utility is currently engaged in power ascension and testing of the unit.

Duquesne Light Company's Beaver Valley Unit 2 is proceeding with fuel loading after receiving its fuel loading license on May 28. Commercial operation is scheduled to begin before the end of 1987.

Palo Verde Unit 3, Arizona Public Service Company's 1,221-MWe Combustion Engineering PWR, received its low-power license in March 1987. Although fuel loading was completed in April, testing and operation awaits completion of diesel generator testing. Barring further complications, the utility expects the unit to enter commercial service by October 1987.

Niagara Mohawk's Nine Mile Point Unit 2 (1,080-MWe BWR) began low-power testing in May. Commercial operation is scheduled to begin by the end of 1987.

Fermi Unit 2, Detroit Edison's 1,093-MWe BWR, is undergoing testing at about half power. The company hopes to begin commercial operation by September 1987.

Advanced testing at Cleveland Electric's Perry Unit 1, a 1,205-MWe BWR, is underway. The unit is scheduled to enter commercial service in the third quarter of 1987.

Houston Lighting and Power Company's South Texas Project Unit 1 (1,250-MWe PWR) began loading fuel in June. The unit is scheduled to enter commercial operation by December 1987.

On April 30, 1987, Public Service Company of Colorado's Fort St. Vrain reactor returned to service, after being shut

©NUEXCO 1987

down since May 31, 1986. An NRC order had allowed the plant to restart, but limited power generation to 35 percent pending the NRC's review of safe shutdown analyses. The NRC commissioners now have voted to allow the plant to operate up to 82 percent of the 330-MWe design capacity, and the company plans to begin a gradual power ascension soon.

In other reactor developments, Dairyland Power Cooperative has permanently closed the 55-MWe LaCrosse unit. The LaCrosse reactor had been operating since 1969, and is the sixth commercial reactor to be closed in the USA. The other plants that have been closed are Dresden 1, Fermi 1, Humboldt Bay 3, Indian Point 1, and Peach Bottom 1.

©NUEXCO 1987

NUEXCO

ANALYSIS AND COMMENTARY

ECONOMIC AND POLITICAL ISSUES AFFECTING THE CANADIAN URANIUM INDUSTRY

Introduction

The worldwide view of Canadian uranium production and supply is primarily based on perceptions of high ore grades, rich reserves, and almost unlimited long-term supply capabilities. Canada's status as the world's leading uranium-producing nation reinforces this view; in 1986, Canada produced more uranium concentrates than the next two largest producing countries combined. While this view is accurate, Canada's complex economic and political forces sometimes override otherwise rational production decisions. An understanding of those factors and their implications for a uranium producer is essential to a full understanding of Canada's supply position. For example:

1. Canada's current weak economic performance might tempt federal or provincial governments to impose added taxes or royalties. Canadian producers might respond by raising prices to maintain profit margins or by increasing production to maintain net profits, or some combination of the two. In any case, some government sales assistance, such as relaxing the rules on upgrading U_3O_8 to UF_6, would be needed to enhance Canadian producers' competitive positions enough to support the added burden imposed by government action.

2. Significant shifts in political party balances have taken place, both at the national and provincial level, and those shifts could have far-reaching effects on the uranium production sector. In particular, a victory in the next provincial elections in Saskatchewan by the New Democratic Party (NDP), which is opposed to uranium mining, might greatly hinder the expansion of production in that province, and could even curtail existing production.

The Canadian Economy

Similarities between Canada and the USA often invite comparisons of the two nations, especially because of proximity, trade patterns, alliances, and similarities of language and culture. Although these comparisons can be misleading, they are often the best indicators of relative performance. The relationship of the Canadian dollar to the US dollar is one indicator of Canada's relative economic performance. For many years, the Canadian dollar maintained a rough parity with the US dollar, but since about 1960 it has gradually weakened relative to US currency. Interest rates generally are higher in Canada than in the USA, and although this differential has widened over the past ten years, it has had little strengthening effect on the Canadian dollar.

Canadian per capita Gross National Product (GNP) has declined since 1976, and currently is approximately 85 percent that of the USA. Although per capita debt in Canada historically had been lower than in the USA, the positions have been reversed since 1979 and Canadians on average now carry 13 percent more debt than Americans. In addition, consumer prices have failed to stabilize. In the first quarter of 1987, consumer price inflation in Canada was higher than in any other industrialized country. The decline in disposable incomes which has occurred since the mid-1970s has been aggravated by an unemployment rate of 9.3 percent, a major political concern.

The disappointing economic state of the country, even after three years of solid economic recovery elsewhere in the industrialized world, combined with several unpopular tax increases, has caused a steady decline in popularity of the ruling Progressive Conservative Party (PCP). For the first time since its inception in 1961, the New Democratic Party (NDP) has achieved first place in national polls. The possibility of a two-way contest in the next federal election between the NDP and the Liberal Party (formerly led by Pierre Trudeau) could leave the pro-uranium Progressive Conservative Party completely out of the running.

The Saskatchewan Economy

Mining and agriculture account for 25 percent of the gross domestic product in Saskatchewan. Farm income has suffered with the worldwide oversupply of grain, although federal government equalization payments have averted a potential crisis. Mineral revenues, however, have been greatly reduced by the fall in international oil prices. In response to a provincial deficit which has grown to about C$1.2 billion, the Saskatchewan government is attempting to cut $800 million, or about 20 percent, from total spending.

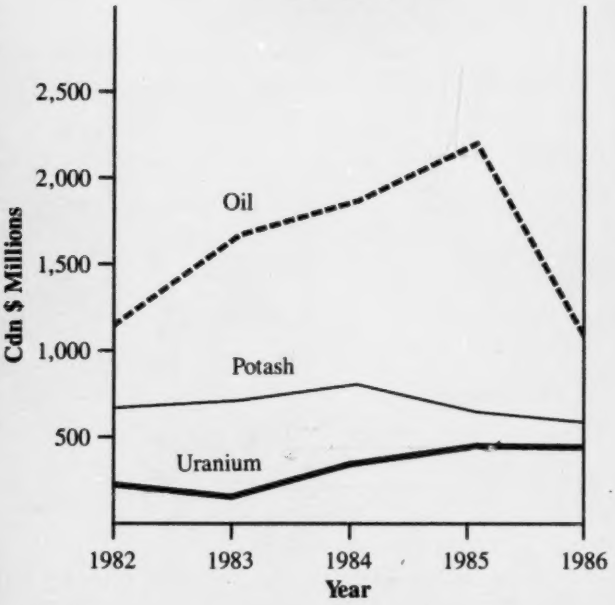
Despite the 1986 increase of 2.5 million pounds U_3O_8 in the province's uranium production, uranium revenues also have leveled off due to contract renegotiations and a greater proportion of market-price contracts (Figure 1). Altogether, Saskatchewan's depressed mineral resource sector is expected to keep the province's economic growth below the national average and, for the first time in many years, Saskatchewan's economic performance may fall below that of the chronically-depressed Atlantic provinces.

The position of the Progressive Conservative Party in Saskatchewan also has eroded. The 1986 election left the party with a majority (Table 2), but the provincial NDP received nearly half the popular vote. In addition, the PCP lost heavily in urban areas. While development of the Cigar Lake mine has the support of the current PCP administration,

©NUEXCO 1987

Figure 1

SASKATCHEWAN MINERAL PRODUCTION 1982-1986



a return to power by the NDP in the next election, to be held in 1989 or 1990, could threaten the future of uranium mining in the province.

The NDP's opposition to uranium production is supposedly based on its objection to uranium's military applications, including sales of uranium to nuclear weapons states and certain other countries, rather than on environmental concerns that have sometimes caused opposition elsewhere. The NDP has announced its intention to halt uranium mining altogether at some unspecified future date, even though party spokesmen have mentioned few details of how the threat might be carried out.

Table 2

SASKATCHEWAN PROVINCIAL PARTY STANDINGS BEFORE AND AFTER THE 1986 ELECTION

Party	Before	After
Progressive Conservative	52	38
New Democratic Party	9	25
Liberal	0	1
Total Seats:	61	64

US-Canada Bilateral Trade

US trade with Canada totaled US$125 billion in 1986; each nation is the other's largest trading partner. Approximately 30 percent of that trade is subject to tariffs. Trade negotiations have been underway for over a year, and the two countries hope to have a free-trade agreement in place by early October. An omnibus agreement would be aimed at eliminating many of those protectionist measures, with the ultimate goal of strengthening the economies of both nations.

Both the Mulroney and Reagan Administrations appear strongly in favor of liberalizing trade. Reagan has long supported free trade in international commerce, and unless the USA can maintain free trade with its largest trading partner, economic accommodation with other US trading partners will be very difficult to achieve. The issue has even greater significance for Mulroney, whose political future could depend on the favorable outcome of the negotiations. The US trade issue is perhaps his most significant foreign policy initiative, and any changes could affect the Canadian economy and unemployment rate. The US market is one of the primary factors affecting the health of the Canadian economy, accounting for more than two million jobs. Access to the US market is not as secure as many in Canada would prefer, and it threatens to become less so. The Canadian government estimates that if the USA were to impose across-the-board trade restrictions as a means of reducing the US trade deficit, the effect on Canadian employment would be dramatic — a ten percent reduction in exports could eliminate 250,000 Canadian jobs.

However, both leaders will face strong opposition to the removal of trade barriers, especially from groups such as the Canadian auto industry and the US lumber industry. Indeed, many Canadians oppose the government's free-trade initiatives. Results of a poll conducted late in 1986 showed a considerable range of opinion on the question of the effects of free trade: 46 percent of Canadians felt free trade with the USA would mean a stronger Canadian economy, but 36 percent disagreed. On the other hand, 43 percent thought that free trade would result in higher unemployment in Canada while 38 percent disagreed. The poll also showed that overall support for free trade has declined steadily, from 58 percent in November 1985 and 78 percent in April 1984.

Beyond responding to nonproliferation concerns, the Canadian government also oversees a number of commercial aspects of the industry. These include review of export contracts, requiring the upgrading of Canadian U_3O_8 in most circumstances, setting guidelines for prices and foreign investment in the mining industry, and maintaining security of supply for the domestic nuclear power program. While

©NUEXCO 1987

many of those practices have been in place since the beginnings of the Canadian uranium industry, all of them appear susceptible to elimination out of economic or political necessity. The remainder of this article examines each of these topics in greater depth.

Canadian Government and Uranium — The Export Review Process

Government review of uranium contracts, initiated in 1969, still is required prior to the filing of an application to the Atomic Energy Control Board (AECB) for an export ·rmit. The original policy statement on contract review was made in 1969 by the Minister of Energy, Mines and Resources:

> "To protect the national interest in the different circumstances which now face us we will henceforth require that all contracts covering the export of uranium or thorium be examined and approved by the appropriate federal agency before any application for an export permit is considered. The examination will cover all aspects and implications of the contract such as nuclear safeguards, the relationship between the contracting parties, reserves, rate of exploitation, domestic requirements, domestic processing facilities, and selling and pricing policy. Approval will not normally be given to contracts of more than ten years duration unless provision is made for renegotiation of price."

In this statement, the Canadian government demonstrated its intention to use the provisions of the Atomic Energy Control Act to exert control over such aspects of commercial uranium marketing as prices and selling policy, which had not previously received overt attention. Government intervention had first begun four years earlier when the Canadian government, by imposing new safeguards conditions, effectively blocked a large uranium sale to France by Denison Mines Ltd., at a price the government considered to be too low. The "appropriate federal agency" became two agencies — the Atomic Energy Control Board and the Department of Industry, Trade and Commerce. In 1983, the Minister of Energy, Mines and Resources made the latest statement on the review process:

> "The review will continue to ensure that contracts are in the national interest. The terms of sale should equitably balance benefits and risks and should generally be in accord with those being obtained by Canadian and international producers for uranium under contracts of similar duration. The review will continue to take into account the implications of such matters as international non-proliferation, the relationship between contracting parties, price and volume of sales to the export market and reserves and rate of exploitation."
>
> Hon. Jean Chretien
> September 15, 1983

The contract review is performed by the Uranium Export Review Panel (UERP), which now includes representatives of the departments of Energy, Mines and Resources (EM&R) and External Affairs, as well as the aforementioned entities. Until recently, three ministers' signatures were required for each approval. Now, however, if the contract requires no exemptions to the policy guidelines, UERP can approve it directly. Contracts requiring exemptions can take 2-4 months for approval, versus 2 to 4 weeks for those not requiring exemptions.

Canada's Upgrading Policy

The Canadian government has required that unless a specific exemption is granted, uranium must be upgraded "to the greatest extent possible" in Canada prior to export, providing the Eldorado Nuclear UF_6 conversion plant has the capacity and is generally competitive with other converters. The policy was reaffirmed in a September 1983 letter to producers which also added the emphasis that "exemption will only be given in highly exceptional circumstances." The compulsory upgrade policy has become more controversial lately for a number of reasons:

1. The Saskatchewan producers cannot sell their entire production as UF_6 because many buyers are already committed to conversion contracts. The existence of the policy and the difficulty and time involved in obtaining exemption often deter buyers.
2. On the basis of the government's continuation of this policy, Eldorado Nuclear has invested heavily in doubling capacity of the Port Hope conversion facility, which is the primary cause of the company's large debt burden. That debt is probably the chief factor in the difficulties surrounding the attempted privatization of the company.
3. The forced conversion concept is often viewed as an irritant in bilateral trade negotiations with the USA, particularly as Canadian producers already are under pressure from pending US legislation and judicial proceedings that could enforce limitations on uranium imported into the USA or tariffs on imported UF_6.

The Minister of Energy, Mines and Resources made the latest official statement on upgrading in October 1985:

> "Ministers now reaffirm the policy that uranium be

refined and converted in Canada before export, provided that Eldorado is generally competitive. This condition applies to competition with other primary converters and not with sales from inventory (the secondary conversion market).

Ministers will permit a limited degree of flexibility for new sales by Canadian producers in the difficult market that is expected to prevail in the near term. 'Exceptional circumstances' now are defined as follows:

1. Exemptions to further processing of Canadian-origin uranium in Canada before export will be granted for those situations where an end user has existing bona fide arms-length conversion contracts, the early termination of which would not be possible without significant financial hardship.

2. Conversion contracts must have been in place on or before December 31, 1980 and must cover the delivery period for which an exemption is requested. Options to extend the conversion contracts would not be considered as grounds for such exemptions, nor would open-ended contracts to cover ongoing conversion requirements. Canadian producers will be required to assist in clarifying the status of end-user conversion contracts, and in satisfying federal officials that uranium sales contracts meet the requirements for exemption as defined above."

According to a report by The Canadian Press, between 1979 and 1983 the Canadian government granted 16 exemptions, covering about 27 percent of total uranium shipments. In the future, however, this is expected to decrease to about 10 percent, as Key Lake producers commit their output. It is conceivable that Eldorado could operate profitably without the upgrading policy, provided that its conversion prices are competitive and are unhindered by currency exchange rates. In any event, as US utilities' contracts with domestic converters expire, the justifications for exceptions will no longer apply, and Canadian producers will encounter commercial problems unless Canadian UF_6 is as competitive internationally as Canadian U_3O_8. Ultimately, the upgrading policy could become a negotiated concession in the US-Canada bilateral trade talks. (A recent report of those discussions indicated that the upgrading policy could be changed at some point in the future.)

However, because of the ongoing litigation between US uranium producers and the US DOE, and because of various Congressional attempts to limit the use of non-US uranium by US utilities, there remains a serious potential threat to Canadian exports of uranium to the USA. At present, the litigation languishes unresolved in the Tenth Circuit Court of Appeals, but the anticipated favorable ruling for the US producers would probably place restrictions on the amount of non-US uranium that US utilities could enrich under their DOE contracts. Legislative attempts to achieve similar ends, such as Senator Pete Domenici's (R, New Mexico) bill restricting the use of non-US uranium to 50 percent of requirements, have not yet succeeded. Nevertheless, Canadian producers stand to suffer the greatest losses if such a law is passed, especially if a total or near-total embargo is enacted. Thus, those attempts to enact severe limitations on the market for Canadian uranium will likely discourage the Canadian government from eliminating or easing the upgrading policy until such threats are reduced or eliminated.

Government Pricing Policy

In 1977 the Minister of Energy, Mines and Resources formulated the government's pricing policy:

> "In the past few years, the rapid price rise which has occurred for uranium and the differing terms of many contracts have resulted in applications for annual export permits containing widely varying prices. In some cases, export approval for old contracts was sought at prices considerably lower than the Board was willing to approve for new sales. In some others, the cost of mining the uranium had overtaken the price. In these cases, or where costs have increased to an extent that selling prices are too low to provide a reasonable return, the Canadian producers are being encouraged to renegotiate their contracts..."
>
> "With regard to all contracts not yet approved by the Atomic Energy Control Board, and all future contracts, the government will expect that terms of sale will provide for an annual renegotiation of price based on then existing world prices giving consideration to such factors as term and size of contract and any special financing arrangements. Provision should also be made for an escalating floor price which will protect investment in production facilities."

Within a few years after this statement was made, the worldwide decline in uranium prices forced the UERP to adopt a more pragmatic view in interpreting the 1977 policy, and the tendency toward market-related prices soon became common. The original philosophy was softened somewhat by the Uranium Resource Appraisal Group in their annual report:

> "All uranium export contracts are required to contain floor prices or similar mechanisms, which protect investment and employment in the uranium production facilities, and pricing terms that provide for an equitable

> balance of benefits and risks and that are in general agreement with those being obtained by Canadian and international producers of uranium under contracts of similar duration."

As a result, numerous recent contracts contain so-called "soft" or "walkaway" floor prices, which are provisions that release the buyer from obligation to purchase if the floor price mechanism acts to his detriment. Exactly how an "equitable balance of benefits and risks" is determined is unclear, but insofar as investment and employment can be protected by selling at prices which barely cover variable costs, heavily discounted sales can be approved. It appears that pricing policy now relates more to direct operating cost than any other single consideration.

Foreign Investment in Uranium

Voter attitudes toward foreign investment in the energy business appear to have changed little during Prime Minister Brian Mulroney's Conservative administration. According to a national poll conducted in April 1987, 77 percent of those polled felt that the federal government in Ottawa should act to prevent the private takeover of Canadian-owned oil and gas companies. The present controversy over the US-based Amoco Oil Corporation's takeover attempt of Canada's largest oil company, Dome Petroleum, is similar to the reaction of the uranium industry to a situation that involved the pending sale of Denison Mines in 1970. That event brought about the current laws pertaining to foreign ownership of Canadian uranium deposits, as implied in the remarks by former Prime Minister Trudeau in March 1970:

> "Last week the government of Canada learned that a substantial ownership interest in Canada's largest uranium mining company might be passed into non-Canadian hands. The government cannot delay making its position clear because it is understood the transaction may be close to completion..."
>
> "...Our reservations about this change of control of Canadian uranium resources are such that if necessary the government will introduce an amendment to the Atomic Energy Control Act, to take effect as of today, to prevent such a transaction."

Since that time, the Canadian government has limited non-Canadian ownership of uranium properties at the production stage to 33 percent. A June 1978 amendment allowed non-Canadian ownership to increase to 50 percent in cases where the property was Canadian-controlled or where development of the property was determined to be "of significant benefit to Canada." In January 1984, the government extended the date for meeting Canadian ownership requirements for up to three years after commencement of production, under the following conditions:

1. The partners in a joint venture in which non-resident participation exceeds 50 percent continue to seek, and report regularly to officials of the Department of Energy, Mines and Resources on efforts to find, sufficient Canadian equity participation to meet the policy requirements prior to commencement of production;

2. The partners in the joint venture negotiate with the Canadian government a mutually agreeable and definitive agreement specifying actions to ensure that the mining project meets the Canadian ownership criteria within three years after commencement of production;

3. A determination is made by the Canadian government that the proposed project, if not Canadian-controlled, will be of significant benefit to Canada.

No further policy statement with respect to foreign ownership of uranium mining has been made since the Mulroney government took office in late 1984. The phrase "of significant benefit to Canadians" has been replaced by "of net benefit to Canadians" in the June 1985 Investment Canada Act, which replaced the Foreign Investment Review Act. To date, the policy on foreign investment in uranium production has not been tested, and reviews under the Investment Canada Act have not halted even one foreign acquisition or new business investment. Figure 2 shows the percentage of investments, by country, made under the Investment Canada Act. This type of flexibility is a change from the past and is not likely to continue if a Liberal or NDP administration is elected, especially if its "opposition" party in Parliament also has a similar political philosophy regarding foreign investment.

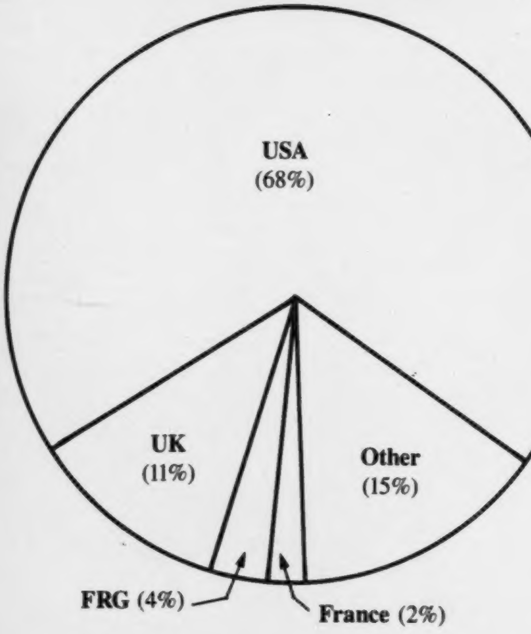
Uranium for Domestic Use

In 1974, a rapid increase in inquiries for long-term supply commitments and projections of a four- to sixfold increase in annual demand for uranium "within the next decade" led the Canadian government to conclude that it should regulate forward coverage in reserves and in milling capacity. This action was deemed necessary to protect Canada's domestic uranium consumers, according to the September 1974 statement by the Minister of Energy, Mines and Resources:

> "Sufficient uranium must be reserved for domestic use to enable each nuclear power reactor operation, committed for construction or planned for operation ten years into the future, to operate at an average annual capacity factor of 80 percent for 30 years from the start of the

Figure 2

1986 FOREIGN ACQUISITIONS UNDER THE INVESTMENT CANADA ACT (TOTAL: 475 ACQUISITIONS)



period, or in the case of reactors which are not in operation, for 30 years from their in-service dates."

The report further stated that utilities were required to demonstrate forward supply contracts sufficient to enable each operating reactor to be operated at an annual capacity factor of 80 percent for at least 15 years, or for reactors committed but not yet operating, for 15 years from their in-service dates. However, the government would encourage commitments to be made for periods of more than 15 years. Previously, the Canadian exporters' contracts were reviewed for safequards implications, the relationship between contracting parties, price and volumes of sales, and reserves and rate of exploitation. Under the new policy, consideration would then also be given to "the adequacy of the contracting company's uncommitted uranium reserves to meet its share of the Canadian domestic reserve margin." Export contract approvals were limited to a maximum of 10 years from the date of signing, with contingent approval possible for an additional 5 years. Domestic utilities could, however, recall part of this contingent tonnage through the AECB.

With the reduction in growth projections for the Canadian nuclear power program, and increases in domestic reserves, the Minister of Energy, Mines and Resources in September 1983 relaxed this policy. Henceforth, the Canadian nuclear program's security of uranium supply would be monitored by examining available supply and contracted commitments on a national basis, rather than examining the situation for each individual producer or utility. In addition, export contracts would be approved for up to 15 years and, in the case of contracts associated with the sale of a CANDU reactor "and where benefit to Canada from such CANDU sale is significant," approval would be given for up to 30 years supply for the unit.

Conclusion

Canada's relatively weak economic performance in recent years could affect the Canadian uranium industry by creating a need to enhance the commercial positions of Canadian producers, and by fostering even greater production among the country's raw materials sector, including uranium. However, potential changes in political structure, both on national and provincial levels, could also have a negative effect on Canada's uranium industry. Additional gains by the generally anti-uranium NDP in the province of Saskatchewan could threaten the future outlook for both for existing operations as well as Cigar Lake and other promising orebodies.

The potential for legislation or regulations in the USA designed to protect its uranium industry presents especially difficult problems for those Canadian producers that rely on sales to US utilities. Trade tensions between the USA and Canada recently have led to Canadian initiatives that support a free-trade situation between the two countries. However, special interest groups on both sides of the border may inhibit these attempts. For the Canadian uranium industry, whose market in the USA represents 20 percent of Canada's annual uranium production, potential restrictions on imports into the USA could seriously damage Canadian uranium revenues. In addition, the Canadian government's UF_6 upgrading policy is certain to be an issue in the context of bilateral free-trade talks. While the government appears to be unwilling to eliminate the policy, it could become a point of negotiation if restrictions on Canada's access to the US market materialize.

The Canadian government's involvement in the commercial uranium business occurs on several levels. At the production stage:

1. Foreign investment in production facilities is limited by law.

©NUEXCO 1987

2. The government may protect the domestic nuclear program's security of supply by reserving a certain amount of Canadian reserves.

After uranium is produced and sold:

3. The Uranium Export Review Panel reviews the contract, examining its compliance with safeguards (non-proliferation) laws, its pricing terms, and including any applications for exemption from upgrading requirements, pending granting approval of the deal.

4. The Atomic Energy Control Board then reviews the findings of the UERB, generally granting approval and issuing an export permit.

Although it is possible some aspects of Canadian government involvement in uranium production and sales will gradually diminish, the influence of politics and economics on the uranium business in Canada will continue to be great, and merit considerable attention by all observers of the world uranium market.

©NUEXCO 1987

ENRICHMENT BLENDING

Introduction

Utilities often hold their uranium inventories in the form of natural uranium. However, as a result of fixed-commitment enrichment contracts, plant delays, and plant cancellations, many utilities hold significant stockpiles of low-enriched UF_6 in their inventories. Many utilities also view this stockpiled enriched UF_6 as less fungible than natural UF_6, and believe that enriched uranium kept in inventory must be at a lower enrichment than that which they ultimately expect to load into the reactor. The assumption is that the inventoried material's lower enrichment can subsequently be upgraded (supplied as enriched feed to an enrichment facility) to the correct enrichment needed for the given reactor reload or first core.

One potential drawback to that strategy is that any future DOE restrictions on the enrichment of non-US-origin feed material probably would apply equally to non-US *enriched* feed material. (Origin of enriched UF_6 is based on the origin of the original feed material.) Some utilities are holding non-US-origin enriched product in their inventories and thus conceivably could be prevented from upgrading it at DOE. The utilities could ship the enriched feed to an overseas enrichment facility, but this might involve contractual disputes with DOE, prohibitive shipping costs, and possible surcharges at other facilities. Enrichment blending is a concept that has been in use by enrichers and fabricators for some time, and it presents a viable alternative to upgrading. Depending on the original enrichment and the enrichment desired, blending costs may be lower than the costs of certain enrichment upgrades.

Enrichment Blending

In theory, enrichment blending is simply the combining of enriched uranium from two input batches having different assays to achieve the desired average product enrichment. For example, blending 10 kgU of 3.4 w/o uranium with 10 kgU of 3.6 w/o uranium will yield 20 kgU of 3.5 w/o product. In this case, there is no loss of feed material, as the equivalent natural uranium contained in the blended product is the sum of the natural uranium necessary to create the ingredients. (No uranium atoms are lost.) However, blending is technically the opposite of the enrichment (or separation) process and some SWU are lost in the blending process.

While it would seem inefficient to "waste" SWU, these losses from blending are small, and their cost may be insignificant compared to the benefits. Figure 3 shows the percentage of product SWU lost if two equal amounts of enriched product are blended to obtain enrichments typical of a 1,000-MWe reactor's reload requirements. SWU lost by blending represent only about 0.01 percent of the SWU contained in the input batches. Assuming each SWU is worth $80, this represents a loss of approximately $800 out of almost $7 million worth of SWU.

Blending losses depend upon the difference between the ingredient enrichment levels; i.e., in blending 3.4 w/o and 3.6 w/o material (having a difference of 0.2 w/o) to obtain 3.5 w/o product, the theoretical loss would amount to slightly less than 0.01 percent of the equivalent SWU contained in the product (Table 3). However, the larger the difference in

Table 3

ENRICHMENT BLENDING EXAMPLE

Ingredient 1		Ingredient 2		Product
10,000 kgU of UF_{6e} at 3.40 w/o		10,000 kgU of UF_{6e} at 3.60 w/o		20,000 kgU of UF_{6e} at 3.50 w/o
	+		=	
Equivalent to* 75,430 kgU feed 41,540 SWU		Equivalent to* 80,290 kgU feed 45,250 SWU		Equivalent to* 155,720 kgU feed 86,780 SWU

Net Feed gain/loss = 75,430 + 80,290 − 155,720 = 0

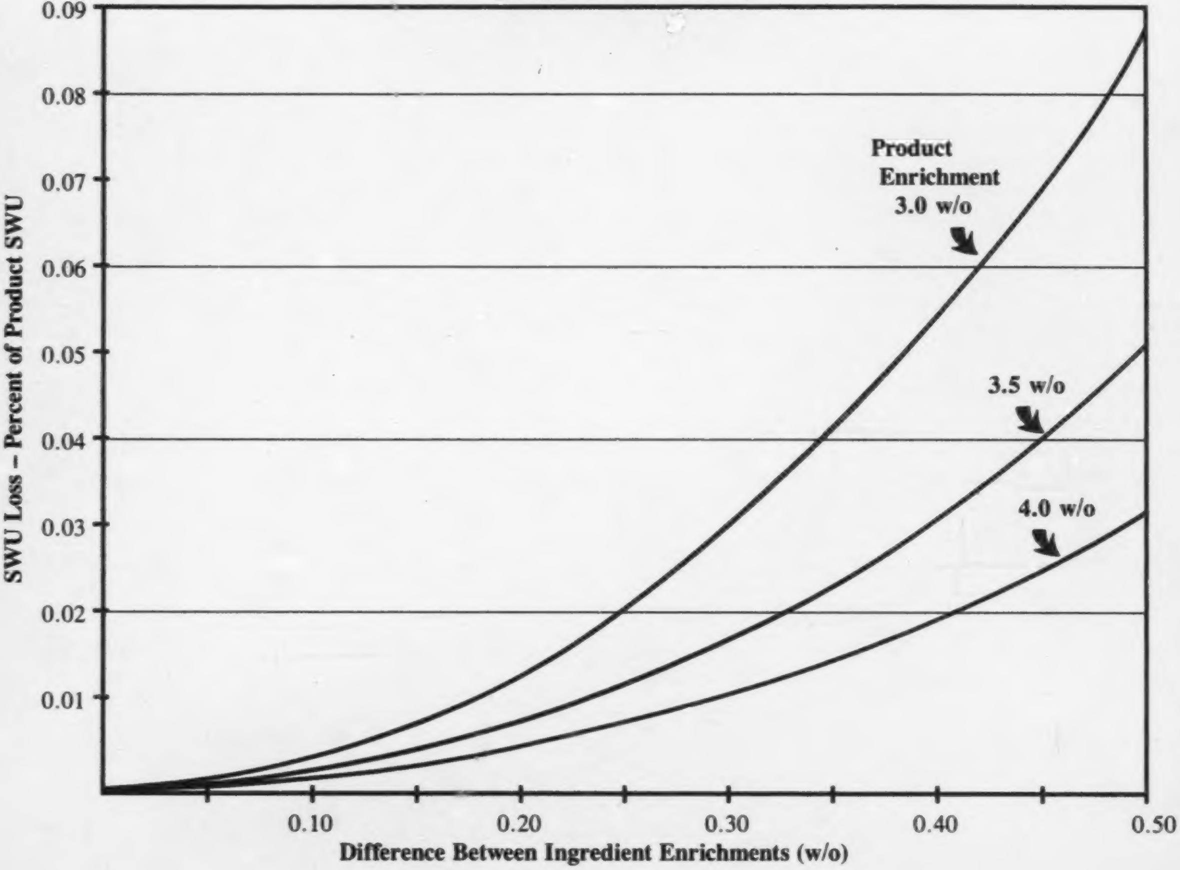
Net SWU gain/loss = 41,540 + 45,250 − 86,780 = −10

Percentage SWU loss = 10/(41,540 + 45,250) × 100 = 0.01152%

* at 0.3 w/o tails assay

Figure 3

ENRICHMENT BLENDING LOSSES
(for equal portions of material)



enrichments between the ingredients, the higher the losses. Thus, if 3.3 w/o and 3.7 w/o materials (having a difference of 0.4 w/o) were blended in equal quantities, the loss would be about 0.03 percent of the equivalent SWU contained in the product, or about $2,500 worth of SWU using the above 1,000-MWe reactor and $80 per SWU example.

SWU losses from blending should be considered in terms of the *relative* cost of upgrading enriched material to the required design level. For example, assuming a utility has inventories of enriched uranium at 3.20, 3.60, and 4.00 w/o, the utility could blend a combination to obtain any product enrichment betweeen 3.20 and 4.00 w/o. The alternative consists of feeding an enrichment plant with 3.20 w/o or 3.60 w/o and performing additional separative work to increase the product enrichment to the desired level. In Figure 4, the losses in the blending process are shown as a percentage of the required upgrade SWU.

Assuming that there are no surcharges or extra costs for the upgrading of enriched product, the upgrade alternative is most attractive if the desired product enrichment is only slightly above the enrichment level of one of the inventoried materials, so that the fewest upgrade SWU are required. The blending option becomes more attractive as the desired product enrichment increases over the enrichment level of the material held in inventory, a situation that would require increasingly more SWU for upgrading. However, even in the worst case, the losses are equal to less than 3 percent of the value of the required upgrade SWU. Therefore, if the SWU

©NUEXCO 1987

held in inventory is valued at three or more percent below the cost of upgrade SWU, the blending process would always be less expensive than upgrading. Blending losses could be further reduced by holding the inventory in more closely-spaced enrichment categories, although that could increase inventory holding costs and possibly decrease inventory flexibility.

Blending to Reduce Design Lead Time

Enrichment blending can reduce the nuclear fuel design lead time, an advantage which may in itself be attractive enough to induce utilities to maintain enriched product inventories and blend them to achieve final design requirements. The design lead time for a typical reload fuel batch is shown in Table 4. For a reactor using annual refueling, in which the reactor may operate for 10 months and spend 2 months undergoing refueling and maintenance, the design-enrichment-fabrication cycle requires a considerable amount of time to finalize the design parameters before the plant is restarted from the previous refueling outage. If the actual operations are different than the design projections, this may cause reduced uranium utilization, reduced operating margins, and/or reduced power capability. The reduction in uranium utilization efficiency is significant; actual discharge exposure of fuel is on average 3-5 percent less than the theoretical exposure, and a significant portion of the lost efficiency can be attributed to the conservatism required when designing fuel enrichment levels prior to establishment of the actual operating parameters.

It would be possible to reduce the design lead time with a blending facility, by keeping stocks of enriched uranium at standard enrichments, and then blending to meet utility specifications. For example, assume that each fabricator has a blending facility with inventories of enriched uranium from 1.6 w/o to 4.4 w/o U_{235} at 0.40 w/o intervals. These stocks could be blended on short notice to obtain almost any enrichment required for power reactors.

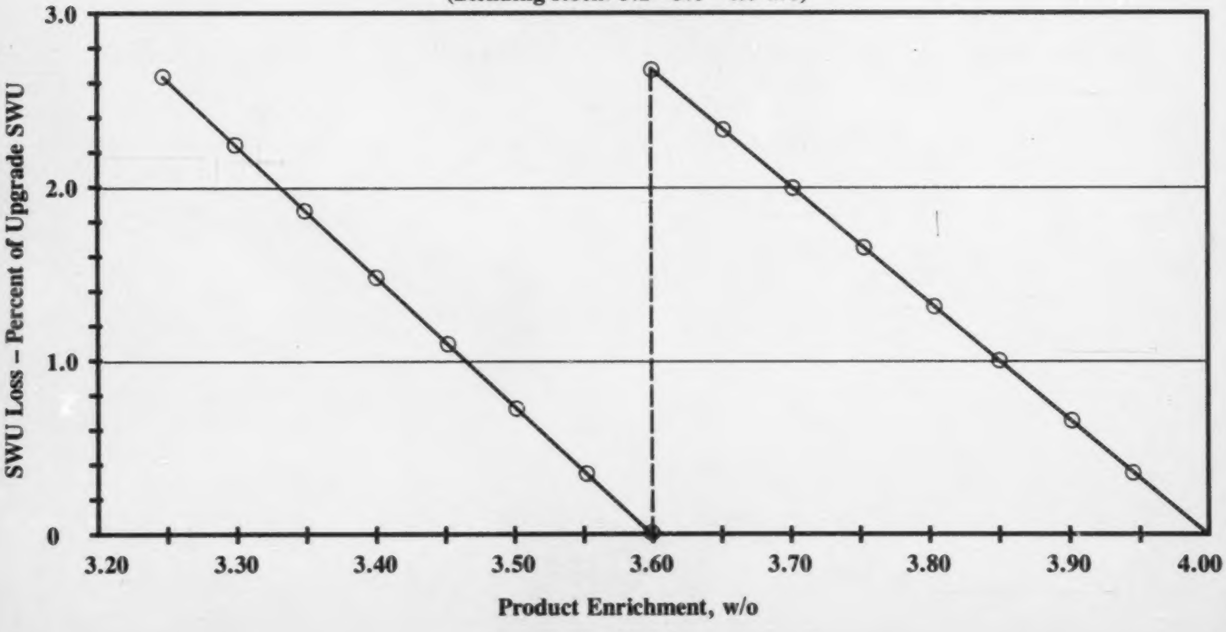
Markets for Blending as an Alternative to Upgrading

There are two potential markets for blending as an alternative to upgrading:

1. *DOE customers* — The US Tenth Circuit Court of Appeals is currently considering a decision which obligates DOE to restrict the enrichment of non-US-origin uranium destined for use in US reactors. If the decision is upheld, this restriction also probably will apply to upgrading enriched UF_6 (UF_{6e}) inventories. US utilities wanting to upgrade the enrichment level of their non-US-origin UF_{6e} could be forced

Figure 4

BLENDING VERSUS UPGRADING
(Blending stock: 3.2 - 3.6 - 4.0 w/o)



©NUEXCO 1987

Table 4

TYPICAL SCHEDULE FOR NUCLEAR FUEL DESIGN

Time (Months)	Schedule
0	Utility provides nuclear fuel designer with shutdown exposure and energy requirements for following cycle.
1	Designer provides utility with information about required enrichment and quantity. Utility provides enrichment supplier with 180-day notice.
7	Enrichment supplier delivers enriched UF_6 to fabricator. Designer completes licensing analysis and confirms applicability of design.
10-11	Fabricator delivers reload batch to site.
11-12	Fuel is inspected and made ready for loading.

to ship their material to Europe for upgrading. In addition to the transportation expense involved, procurement of non-DOE enrichment services may be in conflict with existing DOE enrichment contracts. Utilities planning to purchase UF_{6e} inventories of canceled plants and have the material upgraded at DOE could be similarly affected.

2. *Non-DOE customers* — While DOE does not have a surcharge for enriched feed material, at least one European enrichment supplier has a upgrade surcharge equal to 2 percent of the current price of the SWU contained in the feed. For the material in the above example (Table 3), this surcharge would amount to between US$175,000 and $250,000, depending on current prices. Faced with this surcharge, one European utility recently found it advantageous to transport enriched feed from Europe to DOE for upgrading, and then retransport the upgraded material to Europe. The shipping costs for UF_{6e} across the Atlantic and back total about $0.30 per SWU, or about $25,000 for the material in the example. Blending is potentially much cheaper than either of these alternatives, since the losses incurred through blending would total only about $1,000 to $3,000.

DOE has developed a tentative proposal to blend enrichments, currently referred to as its "REFLEX" program. Under the program, DOE would keep stocks of enriched uranium at each US fabricator, and the fabricator would blend the proper enrichment from the stocks as part of the fabrication process. The REFLEX program has the potential of cutting the design-enrichment-fabrication cycle by up to 180 days, and DOE has indicated that the efficiency gained by standardizing enrichments at the enrichment facility would allow DOE to absorb the SWU lost in the blending process at no cost to their customers. The REFLEX program could require establishment of blending facilities at fabricators which currently do not have them, but UF_6 blending facilities are relatively simple and inexpensive compared to the benefits of such a program.

Conclusion

Enrichment blending is not a common technique for increasing the enrichment levels of inventoried material, but it is one that may offer a cost-effective and time-saving way of achieving desired enrichment levels. SWU "losses" incurred in the blending process generally are slight and may be insignificant relative to the overall cost of upgrading to a specific design level. As an option to upgrading, blending could potentially become more attractive to DOE customers if restrictions are placed on upgrading non-US-origin enriched product at DOE facilities.

©NUEXCO 1987

DECOMMISSIONING OF NUCLEAR PLANTS, PART 2

Part one of this two-part article appeared in Report 226, June 1987.

Introduction

The presence of significant levels of radiation makes the decommissioning of nuclear power plants much more difficult than the decommissioning of fossil-fueled plants. Decommissioning work done to date has shown that nearly all of the radioactivity in a plant after shutdown and defueling comes from neutron-activated materials of the reactor pressure vessel and internal parts, biological shielding, and containment structure. Cobalt-60, a radioactive isotope with a half-life of about 5 years, is formed mainly in steels and dominates the radiation spectrum of the plant for at least 50 years after shutdown. Even though nearly all the radioactivity is found in the central plant area, less than ten percent of the volume of radioactive waste products come from these activated materials. Surface contaminated materials of considerably lower radioactivity account for the great majority of waste.

Much of the technology necessary for dismantling nuclear plants is already in existence or under development. Various techniques and tools for cutting apart equipment and for decontaminating radioactive surfaces are already in use, and are being refined. The need for remote systems in decommissioning work depends greatly upon the length of time a plant is to be stored before initiating the dismantling process. The longer the radioactive isotopes are given to decay, the greater the role humans will have in doing the work. Already, robotic technology is being developed for use in nuclear plants, for regular monitoring and inspection, for maintenance, and for future dismantling.

Many decommissioning cost studies have been conducted over the past decade. While there are substantial variations, most studies of large-scale commercial plants estimate the costs of fully decommissioning a nuclear unit at between $100 and $200 million. Two variables in particular have the potential to greatly increase these costs — higher costs for waste disposal and higher costs for regulatory compliance. Waste disposal costs have risen dramatically in recent years, especially in the USA, and commercial decommissioning of a number of plants could lead to much increased regulatory activity.

Radiological Considerations

The presence of radiation adds unusual hazards to decommissioning of nuclear power plants. Other than the nuclear fuel, nuclear plant components and materials are made radioactive either by *contamination* or by *neutron activation*. Each type poses different challenges and each affects the schedule for decommissioning in different ways. Radioactivity coming from contamination occurs primarily on the material surfaces, by physical contact with other radioactive substances. By contrast, certain materials become activated through exposure to neutron radiation, which creates radioactive isotopes of some of the elements that constitute the material. Thus, while a contaminated surface may often be rendered "clean" (within established standards) by treating the surface, the radioactivity in an activated material is integral to the atomic structure of the material and cannot be altered except by the natural decay of the active isotopes. It is estimated that in light-water reactors, as much as 99 percent of the unit's total inventory of residual radioactivity is produced from neutron activation, nearly all of which is found in the reactor's pressure vessel and internal parts, biological shielding, and nuclear steam supply system.

Dealing with the radiation hazards found in the highly activated materials of the reactor's pressure vessel, primary cooling system and shielding imposes a different set of problems than those needed for surface decontamination. Many of the isotopes are highly unstable, and some have half-lives that are orders of magnitudes longer than the human lifespan. The steel alloys used to make the reactor pressure vessel and supporting structures, as well as steel used to reinforce the concrete shielding and containment structure, contain substantial amounts of cobalt and nickel. Isotopes of these elements — Cobalt-60 and Nickel-59 — are two of the principal products formed by neutron radiation.

The most significant residual activation product present in the plant's central reactor area is Cobalt-60. It is a strong gamma radiation emitter with a comparatively short half-life of 5.3 years, and is a component or trace-element of nearly all steels, especially stainless steels.* Cobalt-60 dominates the radionuclide inventory over the first hundred years after plant shutdown, even though after 53 years (10 half-lives) its radioactivity level is only 0.1 percent of that found at the time of shutdown (Figure 5). Experience from the UK's Windscale decommissioning project has shown that while stainless steel components account for only about five percent of the mass in the reactor, they are responsible for about 75 percent of the residual radioactivity.

---

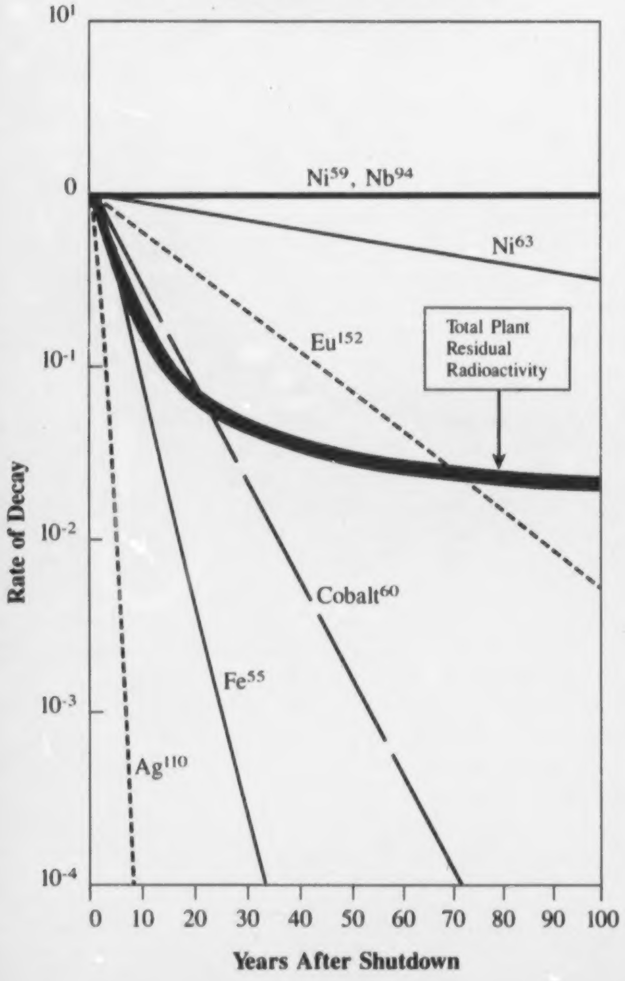
* The three types of radiation emitted in the decay of radioactive materials are alpha, beta, and gamma radiations. Alpha radiation consists of the emission of helium nuclei (2 protons and 2 neutrons). Beta radiation consists of the emission of free electrons, and gamma radiation consists of the emission of electromagnetic energy (similar to X-rays but originating from the nucleus). Half-life refers to the amount of time it takes for a material's radioactivity to diminish by half.

© NUEXCO 1987

Nickel-59 is produced in smaller quantities and is a comparatively low-energy (beta) emitter, but has a half-life of 80,000 years. Over any of the currently anticipated timeframes for decommissioning, Nickel-59 and other such long-lived isotopes would not undergo any meaningful level of decay, making their disposal more difficult than would be the case for isotopes with relatively short half-lives. Other activation products found in nuclear plant materials include Nickel-63 with a half-life of 100 years, Niobium-94, a gamma-emitter with a half-life of 20,000 years, and Iron-55, an x-ray emitter with a 2.4-year half-life.

Figure 5

DECAY RATES OF SOME COMMON RADIOISOTOPES FOUND IN NUCLEAR PLANT MATERIALS



One problem in estimating future radioactivity levels of activated materials stems from the high degree of variability in the amounts of alloy or trace elements found in plant equipment. Cobalt and niobium concentrations in steel may vary as much as tenfold, and trace elements present in the concrete of containment vessels are especially hard to control. One of the lessons being learned from decommissioning projects is that careful attention to materials specifications, and avoidance, where possible, of the use of cobalt and nickel-intensive alloys such as stainless steels and stellite, can make decommissioning less time-consuming and dangerous.

The amount of radioactivity found in the central areas of a nuclear reactor is primarily a function of the size of the plant and how long it has been operating. Thus far, no full decommissioning projects have been undertaken that closely approximate what will be encountered in dismantling a 1,000-MWe or larger plant that has operated for 30 or more years. The radiation levels in and around the reactor pressure vessel could require remote monitoring, inspection and dismantling for at least fifty years after plant shutdown.

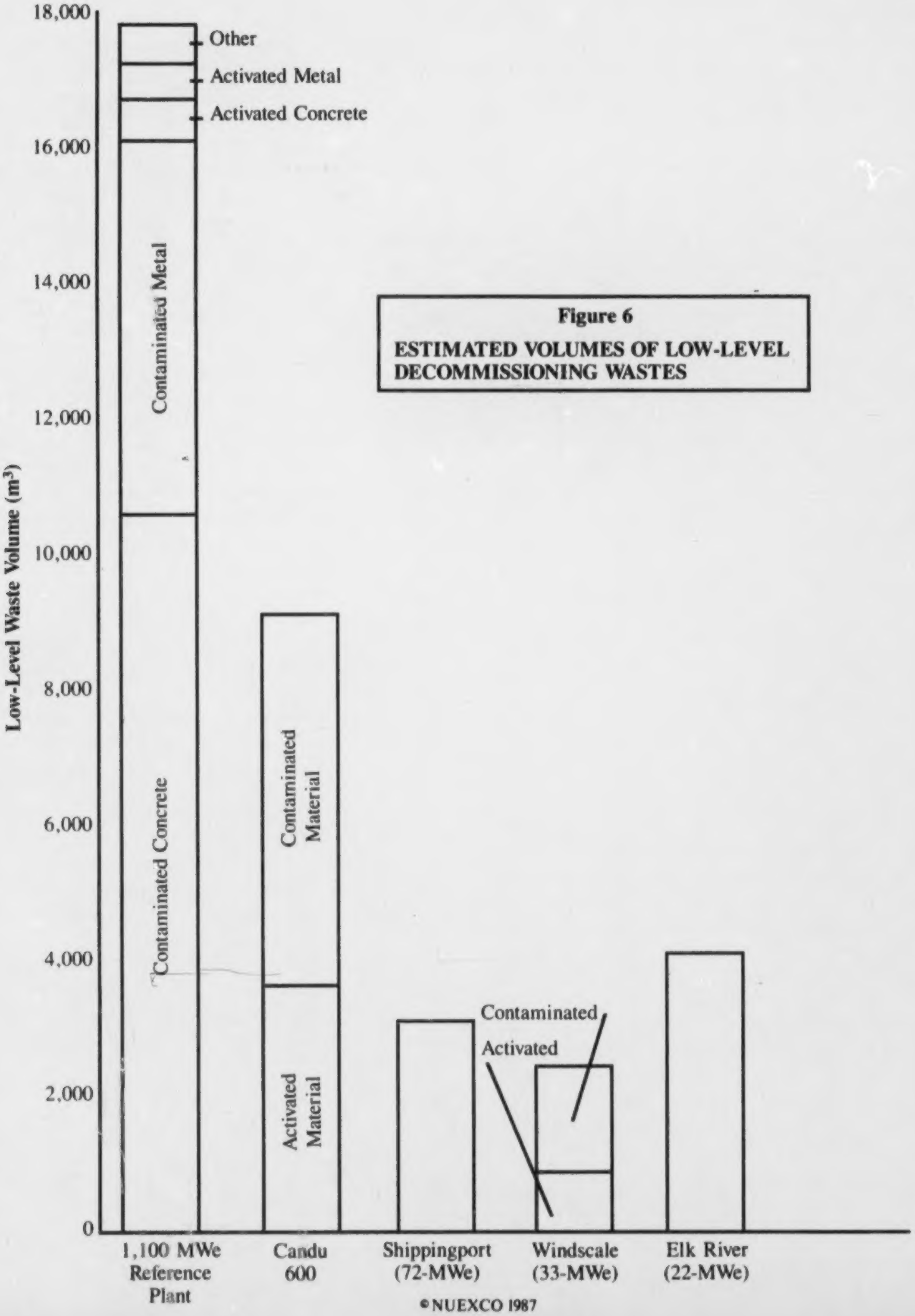
Disposing of Decommissioned Plants

As the country with the most nuclear plants, the USA's efforts to solve the problems of waste disposal have been closely watched by the other nuclear nations. For high-level waste, the US government took a significant step forward when it passed the Nuclear Waste Policy Act of 1982, legislation directed toward the site selection and construction of at least one geologic repository for highly radioactive nuclear waste. The proposed repository program has since encountered a number of obstacles, and although some progress has been made, the program may be in jeopardy. But aside from the problems of the repository program, the nuclear wastes it is meant to handle consist almost exclusively of spent reactor fuel; little or no provision has been made for high-level decommissioning wastes. Even excluding reactor spent fuel from decommissioning wastes, the volumes of low, medium, and high-level wastes from one large commercial plant alone are substantial.

In 1978, NRC estimates for a reference 1,100-MWe PWR showed the bulk of low-level waste products coming from surface contaminated materials; about 16,000 cubic meters of contaminated metal and concrete are in this category. In addition, nearly 1,200 cubic meters of activated metal and concrete, and approximately 600 cubic meters of other radioactive products are included in low-level waste estimates, for a total of about 18,000 cubic meters (Figure 6). For perspective, this is about 1.5 times the amount of other low-level wastes generated during the reference plant's operating lifetime, and is equal to about one-fourth of the total low-level

Figure 6

ESTIMATED VOLUMES OF LOW-LEVEL DECOMMISSIONING WASTES



©NUEXCO 1987

radioactive waste shipped to commercial US waste dumps every year. Thus, decommissioning four commercial-size reactors per year would approximately double the present annual volume of low-level waste shipped to disposal sites in the USA.

Nearly all intermediate and high-level waste comes from the reactor pressure vessel and internal parts. Of the total plant waste, it is estimated that *less than seven percent* by volume will be of activated materials, which constitute nearly all of the plant's residual radioactivity. Those materials alone will require shipping in gamma-shielded containers. How long a plant is kept stored before dismantling is attempted has a great bearing on the amount of radioactivity (and therefore the categories of wastes) that will be encountered. According to recent NRC estimates, three years after shutdown total residual radioactivity in a 1,175-MWe reference PWR drops from approximately 4.9 million curies to 2.5 million curies. After 100 years, the total activity level is estimated to diminish to about 100,000 curies.

Given the very limited availability and capacity of waste dump sites in the USA, and in other countries as well, it is questionable whether, at present, even one large commercial nuclear plant can be dismantled fully. Without greatly increased access to disposal facilities, long-term storage or entombment may be the only real alternatives for the near future.

Decontaminating Plant Equipment

Decontamination methods have been highly developed for plant maintenance and equipment disposal. Although more than 90 percent of a decommissioned nuclear plant's waste volume comes from equipment and materials affected by surface contamination, only about one percent of the plant's total residual radiation is found on this contaminated material. The aim of decontaminating a surface is to reduce the level of radioactivity so that the equipment or material can be reused, to reduce personnel exposure during decommissioning procedures, or to reduce waste volume. Much or all of the surface's radioactivity will be entrained in the effluents or products of the decontamination process, reducing waste volume. Even though the amount of radioactivity found in contaminated material is so much less than that found in activated products, it is spread over many types of components.A judgment may have to be made as to whether it is worth the cost to decontaminate the material or equipment in question. It may be cheaper simply to dispose of the material as low-level waste. However, because the costs of waste disposal are a function of volume, if a large volume of material can be decontaminated, substantial cost savings could be realized.

Before decontamination procedures can begin, a thorough evaluation must be made of the materials' chemical nature, types of radionuclides present, and penetration depth of surface contamination. Only then can the operators of a decommissioning project select the best (of the many possible) techniques for the surface in question. In choosing decontamination methods, efficiency is judged by a combination of costs, effectiveness, and minimum production of contaminated particles, aerosols, or fluids that themselves become radioactive wastes.

Most nuclear plant waste materials that must be decontaminated are either concrete or steel. Generally, since radioactivity comes from particles deposited on the material's surface and does not penetrate into the material, decontaminating involves removing the surface deposits or surface layer of the material. Normally, chemical or mechanical methods are used for surface treatment. Chemical techniques normally are used for metal surfaces while mechanical methods may be used either for concrete or metal. Chemical methods are classified by their degree of aggressiveness, and often the more aggressive the method, the more difficult the treatment of the waste produced by the process. The operator must consider whether to decontaminate the equipment or material in-place or to dismantle and remove it from the reactor or plant area, in order to better control the cycling of the chemicals. Under controlled shop conditions, the creation of excess effluents can be minimized. Some common methods include using ultrasound in conjunction with chemicals to loosen contamination in crevices, electro-mechanical "pickling" to control the depth of surface removal, and the use of liquid freon to penetrate very small fissures and holes.

Mechanical decontamination can be used on all surfaces, by grinding, brushing, or abrading the surface. These methods tend to create substantial amounts of particulate waste products, whose dispersion may be difficult to control. Other methods may be required for cases of deep surface penetration, such as in rough concrete. High pressure abrasive jets, using water or glycerine, may be required, or the use of oxygen or plasma-arc torches, or even high-frequency microwaves. In all cases, the decontamination procedure must account for containment of waste smoke, fluids, particles and other debris.

Technology for Dismantling

Dismantling the radioactive parts of a nuclear plant involves a great deal of unbolting, cutting, and perhaps even the use of explosives to reduce the pieces to a manageable size for removal to waste disposal sites. Whether the dismantling can be done by plant personnel or by means of remote or robotic equipment will depend on the radioactivity level.

©NUEXCO 1987

Much of the material in the reactor will have to be cut apart, probably using acetylene or other types of torches. The thickness of materials can vary greatly — from steel no more than a couple of millimeters thick to a PWR reactor pressure vessel with a thickness of 300 to 600 mm. Reinforced concrete may be as much as several meters thick. With such variable materials, which will exhibit various degrees of contamination and activation, specialized equipment will have to be used. The choice of method and equipment must minimize the amount of uncontrolled aerosols, smoke, particles or fluids that are dispersed, and the equipment itself must resist contamination and allow easy cleaning.

Either thermal (including electrothermal) methods or mechanical cutting methods may be considered for most materials. Thermal cutting includes oxygen torches, electrothermal lances, or plasma-arc devices. Mechanical techniques involve various types of saws, abrasive wheels or disks, drills, pneumatic or hydraulic hammers, or abrasive high-pressure water jets. Thermal cutting methods generate substantial quantities of aerosol materials, while mechanical devices generate solid particulates or liquid effluents. Other methods may also be used selectively. Lasers have the potential to cut steel or concrete, and directional, highly controllable explosives are being considered for certain types of demolition.

In the United Kingdom, two methods are approaching the demonstration phase on the Windscale AGR decommissioning project. The first, being developed by the UK Atomic Energy Authority in conjunction with the engineering firm Strachan & Henshaw, is a 2.5-meter diameter diamond-tipped circular saw, capable of cutting to a one-meter depth in concrete. This saw is mounted on a crane, and is intended to cut the reactor's containment shell. The second method involves what is termed the remote dismantling machine. This machine will consist of a rotating shield platform mounted above the reactor and a rigid mast containing a manipulator arm that descends into the reactor vault. The manipulator arm will carry cutting tools, such as an oxygen-propane torch with an iron powder injection system for cutting stainless steels, and will segment all material, and transfer it to racks or baskets that can be removed to the special waste packaging building that is part of the project. The remote dismantling machine is scheduled to begin operating in 1991, and disassembly of the reactor pressure vessel and internal parts will continue for several years.

In Japan, the Japan Atomic Energy Research Institute (JAERI) at Tokai is involved in development of a number of cutting tools, as part of an overall program to create plant decommissioning technology. An experimental plasma-arc cutting machine is under development for use on the Japan Power Demonstration Reactor's (JPDR) pressure vessel. The 12.5-MWe BWR was shut down in 1976 after 13 years of operation. JAERI expects to use the $2.5 million tool to cut a mockup pressure vessel, continuing through the summer of 1987, before attempting to work of the actual pressure vessel. The plasma-arc saw operates by passing a high-voltage direct current between a rotating "blade" electrode and the material to be cut, generating a moving arc in a gas atmosphere. The tool will cut up to 200 mm-thick steel, operating under water and using argon and hydrogen or nitrogen gas. Segmenting the reactor pressure vessel and core equipment is scheduled for 1988.

JAERI also is testing methods for cutting or demolishing the neutron-activated concrete biological shielding at JPDR. The machinery chosen must be compact, to operate within the containment structure, and must minimize airborne particulate and aerosol materials. Some of the methods being evaluated are kerosene-oxygen flame jet cutting, mechanical cutting with diamond-tipped saws, highly controlled explosive charges, and laser cutting techniques. Other organizations in Japan are testing the use of arc gouging and oxygen gas tools for cutting steels and disc or wheel-type cutters and shearing tools for concrete.

Remote Technology in Decommissioning

Almost regardless of the length of time a reactor is allowed to "cool off" before decommissioning is attempted, dismantling its high-radiation central areas will require the use of remote systems. Development of both fixed-position and mobile "robots" has been underway for some years in a great many industries and for various applications. Many types of robots have been developed for use in nuclear power plants, and some of these will be readily adaptable to the requirements of plant decommissioning. Robotic technology is used for various reasons, but the primary one is to reduce radiation exposure to workers, and to perform operations that would not be achievable by ordinary methods. In the case of decommissioning, robots also will allow a drastic reduction in the length of time a plant must be stored before it can be dismantled, and could provide a substitute for scarce or unavailable skilled labor.

Since remote devices for decommissioning are intended for use in radioactive environments, they must be designed to conform with certain general requirements.

1. They must be "hardened", so that radiation does not interfere with their operation.
2. They must be easy to decontaminate after exiting from contaminated areas, especially as some operations could result in extensive contamination.

3. They must be exceptionally reliable and durable, because failure within certain plant areas could make them difficult to retrieve.
4. Depending on their function, they must be highly mobile.
5. The interface with human operators must be simple, effective, and easy to maintain.

The remote devices likely to be used in plant decommissioning fall into a few general categories, each with fairly specific functions and design requirements.

Monitoring, Surveillance and Visual Inspection — Robots for plant radiation monitoring are already entering fairly widespread use in the nuclear industry. Their function often requires a high degree of mobility, and monitoring robots have been designed with treads, wheels, and multiple legs. Some of these are able to climb stairs and maneuver over short walls and other obstacles. Some are self-contained, using batteries for power, and others operate with an umbilical connection providing power and control functions. Monitoring and inspection robots generally do not have to exhibit a high degree of manipulative ability, beyond perhaps taking smear samples on various surfaces. They also need not be large in size, or be able to handle heavy objects; in fact, they tend to be rather small and lightweight, especially those operating under battery power.

Decontamination — Another use of robots is in decontamination. They have already been employed in numerous nuclear plant maintenance operations, and for routine cleaning and decontamination of nuclear steam supply systems and other operating machinery, as well as in post-incident cleanups. These types of operations require the ability to manipulate high-pressure washers, for example, or mechanical scouring systems, and therefore must combine mobility with precision movement and manipulation of tools. Such robots tend not to be battery-operated, but have cable and hose connections supplying power and communications.

Dismantling Equipment — A high-degree of manipulative ability, coupled with a substantial lifting capability, will be needed for robots designed to unbolt and dismantle plant equipment. It remains to be seen whether it will prove more cost effective simply to cut apart or to unbolt much of the piping and valving in a plant.

Cutting Equipment — Robots already are in use as remote welders, operating inside pipes and other areas inaccessible to human welders, and adapting these high-precision robots to perform gas-torch cutting should not prove difficult. Remote-controlled cutting machines generally fall into two types: large, semi-fixed position tools, and highly mobile robotic vehicles. Cutting of pipes, valves and other peripheral equipment thus presents very different requirements from cutting apart thick, highly activated reactor pressure vessels and internal parts, concrete shielding and containments.

Handling and Transporting — Specialized robotic equipment will be needed to lift and move the parts dismantled by cutting equipment, and perhaps decontaminated by other robotic machines. Some of these transport machines probably will be in the form of rail-type, fixed position equipment designed to move already handled parts from the plant floor to a handling area, and from there to a transport area. These may have to be able to lift and move several tons of weight. Other robot handlers will be needed to move pieces of sectioned plant equipment to specified locations for loading into "crates." Most of these robots will have to be able to lift at least 200 kg in weight, and may be programmed to perform in a repetitive manner, similar to existing factory robots of today.

Packaging and Handling Equipment — Separate systems will have to be provided for packaging the radioactive materials removed from the plant, in several waste categories. These systems probably will incorporate volume reduction and compaction machinery and placement equipment, so that sealed casks can be taken from the site directly to disposal areas. Such equipment already is available.

Remotely Operated Construction Equipment — Many tasks can be performed by ordinary construction equipment, such as cranes, backhoes, forklifts, front-end loaders, etc, if they are converted to remote operation. Such conversions are already available for hazardous and underwater construction.

Certain areas have been identified that will need considerable development for use in decommissioning nuclear plants. Most self-contained robots, now largely used for monitoring and inspection, have rather limited operating times. Their battery systems often are capable of no more than one hour of sustained use before the unit must return to where it can be recharged, which may take up to 24 hours. Robots with umbilical connections, essentially a thick cable supplying control connections, power for mechanical systems, and possibly such materials as oxygen and aceteylene for cutting torches, have difficulty maneuvering in tight spaces when tethered to the connecting cable. The cable also has definite practical length limits, making it difficult for robots to climb stairs, turn numerous corners, and still perform disassembly operations.

Many or most operations by robots involve a human operator controlling the motions of the robot through either a wired or radio contact. Effective remote manipulation requires a highly sophisticated interface, with tactile and visual feedback. While it is probable that some operations will be pre-programmed, such as a robot inside a section of pipe cutting sections at specified distances, much of the work still will require skilled operator-robot control. Telesensory systems are rapidly evolving and should be quite advanced within a decade, when a greater need for decommissioning of commercial nuclear plants becomes necessary.

One of the greatest tests of robotic technology will probably come not from operating the equipment, but in scheduling of how and when each disassembly operation takes place. Given the complexity of plant plumbing, and the non-standard nature of most plants now in existence, especially in the USA, the precise order of disassembly will be tremendously important. This may seem elementary — the engineers who are familiar with the plant simply work with the schedulers to remove the equipment a little at a time. However, consider the difficulties if a plant is stored or mothballed for 25 to 50 years. There could well be no one available who really knows the plant details after that time has elapsed.

To a great extent, how robots are used will depend on the timeframe of the decommissioning process. Where a need is perceived to move quickly ahead with dismantling, robots will have a relatively greater role than where the plant is to be stored for many years. It is likely that robotic technology will move in the direction required for nuclear plant decommissioning, and that by the time they are needed, robots capable of performing the many tasks involved in plant decommissioning will be widely available and well-adapted to the nuclear industry.

Costs of Decommissioning

Over the past decade numerous studies have been conducted, both by utilities and by other organizations, to determine probable decommissioning costs (Figure 7). These cost estimates have a direct bearing on utilities' arrangements for financing their future decommissioning operations. Given the extensive study of the cost problem, the many details and phases involved are well known. Nevertheless, the available literature on decommissioning costs suggests a wide range of estimates. A major problem in judging the reliability of such estimates is the lack of uniformity in methodologies, and the variables affecting every estimate.

Some of the variables involved in estimating decommissioning costs include:

1. Lack of standardization among nuclear plants;
2. Lack of standardization among cost studies;
3. Differences between generic and site-specific studies;
4. Difficulty in estimating future costs of waste disposal;
5. Uncertain development costs for remote and other specialized tools and equipment;
6. Difficulties in estimating inflation over a prolonged period of storage or entombment, which may be up to a 100 years;
7. Uncertain future regulatory changes;
8. Differences in actual plant types and operating history;
9. Different planned stages of dismantling and timetables for achieving full decommissioning.

To date, no large commercial reactors anywhere in the world have been completely dismantled. In the USA, only the Shippingport, Pennsylvania reactor (jointly owned by DOE and the Duquesne Light Company) is undergoing active decommissioning, and while it will certainly provide considerable cost data, it may not be representative of costs that will be encountered in later, larger projects. The pressure vessel and internal parts of the Shippingport unit are being shipped intact to the Hanford reservation for intact disposal, rather than being segmented and disposed of in a manner similar to what operators will use for large plants. Also, at 72 MWe, it is less than one-tenth the size of most commercial reactors. Decommissioning the Shippingport reactor is expected to cost about $100 million. While much experience will be gained at Shippingport, it is difficult to determine its applicability in estimating costs of large commercial units.

Despite the uncertainties, several very detailed cost studies are available, and give some indication of the probable costs. In 1978, the US Nuclear Regulatory Commission (NRC) commissioned the Battelle Pacific Northwest Laboratory to conduct a study aimed at defining the costs of decommissioning a reference PWR and BWR plant, both having 1,100-MWe capacity. This study was revised and updated in 1984. Also, the Atomic Industrial Forum (AIF) prepared an evaluation of decommissioning costs, which it published in 1983. Several nuclear utilities, such as Canada's Ontario Hydro and the UK's South of Scotland Electricity Board also have released detailed cost studies for decommissioning their own plants.

The updated Battelle cost estimates for reference 1,100-MWe PWRs and BWRs were $104 and $133 million respectively (in constant 1984 US dollars); the estimates assumed immediate dismantlement through Stage 3, with a 25-percent contingency factor. A comparative *site-specific* category showed higher costs for the PWR case ($140 million in 1984 constant dollars), while the BWR remained essentially unchanged at $134 million. If instead of immediate dismantlement, a 50-year safe storage period is used for the generic PWR case, the cost drops to about $97 million, and for a 100-year entombment scenario the cost declines further, to about $84 million, both in 1984 constant dollars.

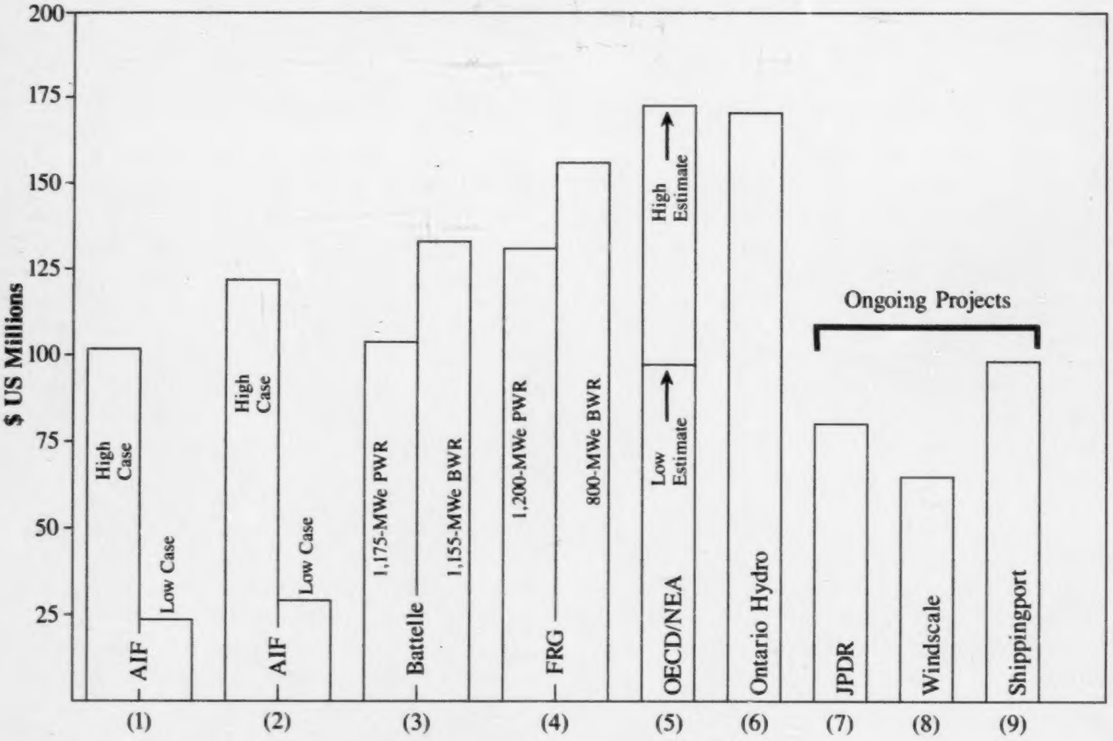
Studies conducted by the AIF estimate costs for immediately dismantling both types of plant to be much lower. The PWR case average is projected to be $54 million, with a high estimate of $102 million and a low estimate of $24 million; in the case of the BWR costs average $65 million, ranging from

©NUEXCO 1987

BASIC CONSIDERATIONS

Figure 7

SELECTED COST ESTIMATES FOR NUCLEAR PLANT DECOMMISSIONING



1. AIF estimate for immediate dismantlement of large PWR, constant 1980 US dollars.
2. AIF estimate for immediate dismantlement of large BWR, constant 1980 US dollars.
3. Battelle Pacific Northwest Laboratory estimate for immediate dismantlement of reference PWR, and BWR, constant 1984 US dollars.
4. Association of German Electric Power Utilities estimate for immediate dismantlement of reference 1,200-MWe PWR and 800-MWe BWR, constant 1984 US dollars.
5. OECD/NEA survey, cost estimates for immediate dismantlement of 1,300-MWe LWR, constant 1984 US dollars.
6. Ontario Hydro estimate for immediate dismantlement of Pickering Unit 1, 500-MWe Candu, constant 1980 US dollars.
7. Japan Power Demonstration Reactor (JPDR, 12.5-MWe BWR) cost estimate, undergoing decommissioning.
8. UK Atomic Energy Authority Windscale project (33-MWe AGR) cost estimate, undergoing decommissioning.
9. US DOE Shippingport Reactor (72-MWe PWR) cost estimate, undergoing decommissioning.

©NUEXCO 1987

a high of $122 million to a low of $29 million. For decommissioning to a Stage 1 condition, or mothballing, the PWR averages about $6 million and the BWR averages about $9 million. Entombment costs are estimated to lie between mothballing and immediate dismantlement — the PWR case averages $14 million and the BWR $24 million. AIF notes that the fourfold difference in estimated costs between high and low projections are due to differences in labor rates, plant size and configuration, whether spent fuel is considered part of decommissioning, waste transport variables, inclusion or exclusion of engineering and planning, and variations in degree of required dismantling.

A study made by Ontario Hydro estimated costs for immediate dismantlement of its Pickering Unit 1 (515-MWe CANDU) of about C$200 million, in 1980 Canadian dollars (about US$170 million in 1980). Ontario Hydro's figures include a 10-percent contingency factor and do not consider fuel disposal costs in decommissioning costs. Another study by the South of Scotland Electricity Board (SSEB) showed costs of immediately dismantling its Hunterston Unit B1 (625-MWe AGR) to be 270 million pounds sterling, in 1982 values (over US$500 million in 1982). Other studies by the Association of German Electric Power Utilities, and the Swedish Nuclear Power Inspectorate estimate decommissioning costs of large-scale PWRs to be $130 million and $126 million (in 1984 dollars) respectively. Other industry estimates of decommissioning costs cover a wide range, from 10 percent up to 40 percent of original construction costs.

Current decommissioning estimates for large-size commercial plants generally range between $100 to $200 million. With such a wide spread of cost estimates, and so many variables affecting future costs, it is important to remember the unanticipated escalation in nuclear plant construction costs that took place from the 1970s through the present. To a large extent, nuclear plant decommissioning is a developing technology, which could well be affected by some of the same uncertainties that affected the nuclear construction industry.

Even if the mechanical and engineering aspects of plant decommissioning are reasonably amenable to accurate cost estimating, two areas in particular could account for large future cost increases — costs of waste disposal, and increases due to regulatory change. Between 1980 and 1983, for example, disposal costs of low-level wastes at the disposal site at Barnwell, South Carolina increased more than 600 percent. Since in several of the decomissioning cost estimates, low-level waste disposal accounted for up to or above 40 percent of the total cost, large future increases in disposal costs could affect overall decommissioning costs dramatically.

It is equally difficult to predict how future regulatory trends will affect decommissioning. It is possible that the initiation of several large, commercial decommissioning projects could focus attention on gaps in regulatory procedures, resulting in new rounds of rulemaking and attempts at compliance, with the associated unpredictible and costly effects that characterized the emergence of the nuclear construction industry. In essence, the one aspect of decomissioning cost estimating that stands out is the need for caution in accepting any of the current figures. Perhaps they will prove to be accurate, and they may even decrease with time as economies of scale, maturing technologies, and actual experience enter the picture. Conversely, substantial escalation of costs also is a real possibility.

Conclusion

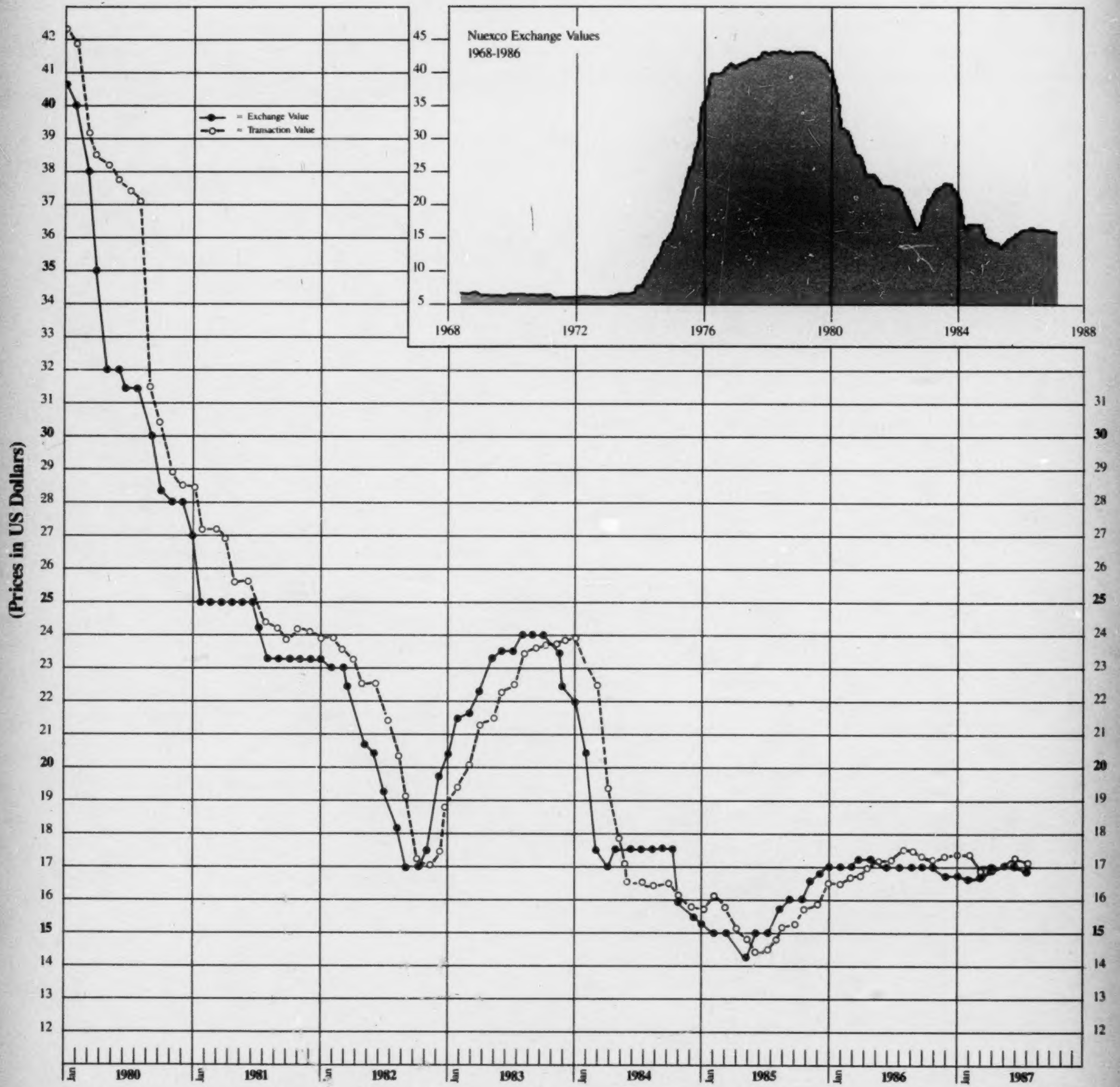
Since the residual radioactivity in a nuclear plant continues to inhibit much of the direct labor in the dismantling process for a minimum of 50 to 100 years after shutdown, some remote technology must be used to decommission the plants. To some extent, that technology now exists, and extensive development is underway in several countries and on at least two decommissioning projects. Both the Windscale and the Japan Power Demonstration Reactor projects will provide much-needed experience in plant decommissioning methods and uses of technology.

One of the least certain aspects of nuclear plant decommissioning is how much it will cost. While numerous studies have been conducted, most of which estimate costs of between $100 and $200 million for typical, large-scale commercial units, two varibles — waste disposal costs and costs incurred due to possible future regulatory changes — could be especially subject to substantial escalation.

The units currently being decommissioned are small by the standards of today's large commercial reactors. Until more experience is gained decommissioning plants representative of the mainstream commercial reactor base, both in size and in operating time, estimating the technical problems and costs will be extremely difficult.

©NUEXCO 1987

HISTORICAL MARKET DATA



©NUEXCO 1987

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	**16.90**						

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	**17.10**						

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	**1.80**						

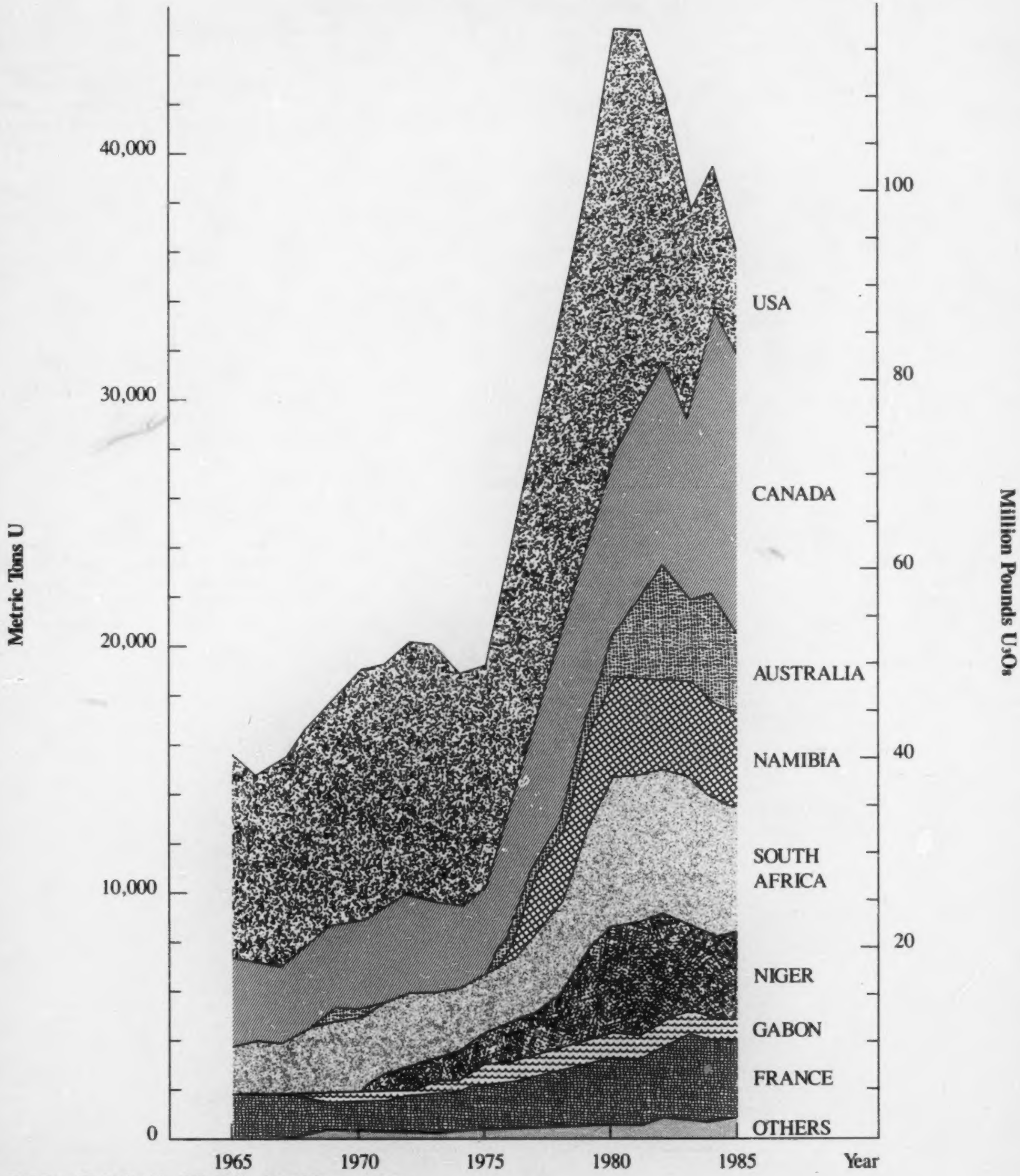
HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	**47.75**						

©NUEXCO 1987

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

©NUEXCO 1987

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity,* DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity,* DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity,* DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983,* DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry,* GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

©NUEXCO 1987

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	**Volume of Deliveries to the EC[2] (in MTU)**	**Percentage of Deliveries Made Under Spot Contracts**	**Medium or Long-Term Contracts[3,4]**		**Spot Contracts[3,4]**	
			Average Price in ECU per pound U_3O_8	**Average Price in US Dollars per pound U_3O_8**	**Average Price in ECU per pound U_3O_8**	**Average Price in US Dollars per pound U_3O_8**
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

GOVERNMENT STATISTICS

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1976 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]	133.6	100.0	—
FY86 Avg.[7]	—	105.0	—
Jan 1986	—	109.6	210.0
Feb 1986	—	108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986	—	94.3	210.5
May 1986	—	93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986	—	98.1	215.3
Aug 1986	—	98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986	—	106.2	215.4
Nov 1986	—	105.2	215.6
Dec 1986	161.5	105.5	215.6
Jan 1987	—	106.4	215.9
Feb 1987	—	109.2	216.5
Mar 1987	164.7	—	217.0

P = Preliminary R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5] Annual averages prior to 1979 reflect index base no longer in use.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

[7] Annual averages are for financial year ending June 30.

©NUEXCO 1987

CANADA

		Wage-earner Data: Average Hourly Earnings (C$)[2]					
	Industry Selling Price Index: All Commodities[1] (1981 = 100)	**Uranium Mines (SIC 057)**	**Metal Mines (SIC 051-059)**	**Mines, Quarries and Oil Wells[3] (SIC 051-099)**	**Primary Non-ferrous Metal Industries[4] (SIC 296)**	**(SIC 298)**	**Chemicals and Chemical Products[5] (SIC 372-379)**
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan 1987	120.0	19.52	16.84	16.07	13.06	12.56	12.95
Feb 1987	119.8	20.33	17.15	16.09	13.01	12.66	13.18
Mar 1987	120.3	20.04	17.15R	16.02R	13.57R	12.58R	13.09R
Apr 1987	121.1R	20.47P	17.36P	16.21P	13.54P	12.33P	13.28P
May 1987	121.7P	—	—	—	—	—	—

P = Preliminary   R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

©NUEXCO 1987

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.70	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	741,032	585,461
Mar	1987	88.17	197.1	255.0	239.6	—	—
Apr	1987	—	—	258.2	242.5	—	—
May	1987	—	—	261.2	—	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2] (1967=100)	GNP Implicit Price Deflator[3,4] (1982=100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967=100)	All Commodities (1967=100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6	298.4	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.16	12.20	9.85
Jan 1987	313.6	300.9	333.1	—	12.94R	12.98R	12.18R	9.84R
Feb 1987	315.7	302.7	334.4	—	12.99R	12.83R	12.21R	9.84R
Mar 1987	315.8	302.8	335.9	116.2	13.04R	12.79R	12.24R	9.84R
Apr 1987	317.4	305.1	337.7	—	13.21P	12.91P	12.28P	9.85P
May 1987	318.6	307.3	338.7	—	—	—	12.31P	9.84P

P = Preliminary R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 to April 1985 are adjusted to the March 1980 benchmark. Data for January 1986 and beyond are adjusted to the March 1986 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan

Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA James G. Munro
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA Chris I. Von Christierson
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES Harold C. Lindberg
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN Kazy Yokota
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN Edward Bee
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES Ralph O. Smith
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

86800-1 A-
8/17/87

NUEXCO

Monthly Report

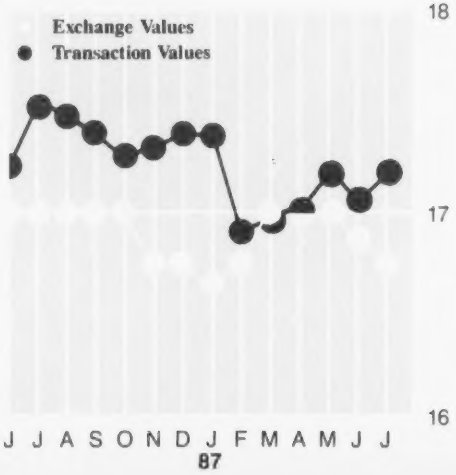
August 1987 Number 228

Appeals Court Upholds Carrigan in Producers vs. DOE Lawsuit 3

US Restricted Market Supply-Demand Analysis 31

Australian Labour Party Wins in July Federal Election 38

Second-Quarter South African Production Results 39



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

CHIEF EXECUTIVE OFFICER — Charles H. Peterson

NUEXCO TRADING CORPORATION

President	Earl E. Hoellen, Jr.
Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

NUEXCO INFORMATION SERVICES CORPORATION

President	R. Gene Clark

Support Services

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

Hans W. Vogt
(Switzerland)

Chris I. von Christierson
(South Africa)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 228
(All data as of July 31, 1987)

Exchange Value
$16.75, down $0.15

The **Exchange Value** is **$16.75** per pound U_3O_8, down $0.15 since last month.

UF_6 Value
$47.50, down $0.25

The **UF_6 Value** is **$47.50** per kilogram U as UF_6, down $0.25 since last month.

Transactions

Eight recent natural uranium sales are reported, involving **1.8 million** pounds equivalent U_3O_8. Seven of the sales involved spot or near-term delivery, and met the conditions for inclusion in the Transaction Value.

Supply-Demand Ratio
decreased to 1.1:1

Active spot and near-term **uranium supply** amounts to **2.8 million** pounds U_3O_8 equivalent, down 850 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.5 million** pounds, up 1.5 million pounds from last month. The spot and near-term **supply-demand ratio** decreased to **1.1 to 1**.

Transaction Value
$17.30, up $0.20

The **Transaction Value** is **$17.30** per pound U_3O_8, **up $0.20** since last month. The calculation includes 18 transactions involving a total of 3.7 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate
unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value
$1.90, up $0.10

The **Conversion Value** is **$1.90** per pound U as UF_6, up $0.10 since last month. No active secondary market supply for conversion services is reported this month. Active demand totals 440 thousand pounds U as UF_6. Three conversion transactions are reported.

SWU Value for
delivery within
one year: $75,
up $2.00

The **SWU Value** at .3 tails and for delivery within one year is **$75** per SWU, up $2.00 since last month. One secondary market SWU transaction is reported.

* * *

Pricing

The US Tenth Circuit Court of Appeals has upheld Judge Carrigan's June 1986 ruling in favor of the producers in the US Producers vs. DOE lawsuit. This section examines in detail the background and history of the lawsuit, reprints the text of the Appeals Court's decision, and discusses what legal and legislative possibilities remain to be taken by DOE and the producers.

Analysis and
Commentary

Nuexco's forecast of market trends under restricted market conditions through 2000 shows diminishing excess inventories, increasing uncommitted supply and increasing unfilled requirements. Several restricted market scenarios are examined in which US production is increasingly stimulated, depending on degree of restriction and other conditions.

Recent Developments

In the recent Australian federal elections the Australian Labour Party (ALP) was returned to power. The ALP's policies toward uranium are expected to remain unchanged in the near term. Labor relations in Australia's uranium mining industry have improved under the ALP's tenure, despite the Australian Council of Trade Unions' nominal opposition to uranium mining.

Second-quarter 1987 uranium output from South Africa's Chamber of Mines producers has declined 5.9 percent from the first quarter of 1987, totaling 2.55 million pounds U_3O_8. Substantial drops in production at Buffelsfontein, Freegold, ERGO and Western Areas accounted for much of the decline.

This Executive Summary may be reproduced for internal distribution.

©NUEXCO 1987

NUEXCO

NUEXCO REPORT 228 FIGURES OF THE MONTH (July 31, 1987)	This Month (Report 228)	Last Month (Report 227)	12 Months Ago (Report 216)
Exchange Value[1]	16.75	16.90	17.00
Transaction Value[1]	17.30	17.10	17.50
UF_6 Value[2]	47.50	47.75	48.25
Loan Rate[3]	3%	3%	4%
Conversion Value[4]	1.90	1.80	1.80
Near-Term Uranium Supply[5]	2.8	3.7	3.9
Near-Term Uranium Demand[6]	2.5	1.0	2.7
Near-Term Supply-Demand Ratio	1.1	3.7	1.4
Recent Uranium Sales:			
Number of Transactions[7]	8	12	7
Quantity of Material[8]	1.8	3.9	1.2
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	75	73	78
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00[11]
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00[13]	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U_{235}	447	443	457
3.0 w/o U_{235}	572	566	585
3.5 w/o U_{235}	699	691	715
4.0 w/o U_{235}	827	818	847

---

[1] US $ per pound U_3O_8 equivalent.

[2] US $ per kilogram U as UF_6.

[3] Per annum.

[4] US $ per pound U as UF_6.

[5] Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[6] Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).

[7] Uranium sales only; does not include loans, conversion, or SWU transactions.

[8] Millions of pounds U_3O_8, equivalent.

[9] US $ per SWU.

[10] Effective 10/1/86.

[11] Effective 10/1/85.

[12] Effective 10/1/84.

[13] Effective 10/1/86, for up to 30% of annual requirements.

[14] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

[15] US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (227)

Section	Topic	Page
Recent Developments	Mid-Year Reactor Progress Update	13
Analysis and Commentary	Economic and Political Issues Affecting the Canadian Uranium Industry	16
Analysis and Commentary	Enrichment Blending	23
Basic Considerations	Decommissioning of Nuclear Plants, Part 2	27
Nuclear Fuel Pricing	*Natural Uranium and Conversion* Pricing in June 1987	1
	Enriched Uranium and SWUs Pricing in June 1987	2

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

August 1987 No. 228

R. GENE CLARK, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWU 2
Ruling in US Producers vs. DOE Lawsuit 3
Transcript of the Appeals Court Decision 7
History of the Producers vs. DOE Lawsuit 13

CURRENT MARKET DATA

Nuexco Market Values 21
Nuexco Market Values Expressed in Selected Currencies 22
Recent Transactions 24
Supply and Demand Tables 25

ANALYSIS AND COMMENTARY

US Uranium Trade Restriction Analysis 31

RECENT DEVELOPMENTS

Australia 38
South Africa 39

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 41
Historical Exchange Values and Transaction Values 42
Historical Conversion Values and UF_6 Values 43
Graph of World Uranium Production 44
US Uranium Marketing Activities Statistics 45
Volume and Price of Uranium Deliveries to the European Community 46

GOVERNMENT STATISTICS

Australia 47
Canada 48
South Africa 49
United States 50

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Information Services Corporation ISSN 0742-4582

To Our Readers

We are pleased to announce that Mr. Chris von Christierson has accepted appointment to Nuexco's International Advisory Committee. Mr. von Christierson has been involved in the gold and uranium industry since 1971. His background includes employment with Gold Fields of South Africa Limited. In 1978 he became Managing Director of Southern Prospecting (Pty) Limited and is currently a director of a number of public mining and exploration companies incorporated in South Africa, Canada and Australia. He holds a Bachelor of Commerce degree from Rhodes University (South Africa) and a Master of Arts (Economics) from Cambridge University (U.K.).

Mr. von Christierson has been Nuexco's representative in South Africa since 1977. He will continue as our representative there, as well as serving on the International Advisory Committee.

* * *

Included in this report as an insert is a copy of the questionnaire that was mailed to our subscribers last month. If any of our subscribers did not previously receive the questionnaire, we urge you to fill it in and mail it back to Nuexco. Your views are very important, and will help us to maintain a high level of service to our customers.

* * *

We would like to remind our readers that Nuexco's full-service subscribers are entitled to certain special services not available to our other subscribers. These services are:

- First-day Exchange Value notification via telex.
- Nuexco's Annual Review Issue.
- Four copies of the Monthly Report.

We would also like to remind our subscribers that the current Exchange Value is available by telephone from any Nuexco commercial representative, or from the editors of the Monthly Report.

* * *

Nuexco will be hosting a hospitality suite at the AIF Uranium Seminar '87, to be held September 13-16 at Keystone, Colorado. We look forward to seeing you there.

© NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of July 31, 1987)

The **Exchange Value** is **$16.75** per pound U_3O_8, down $0.15 since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **2,830,000** pounds U_3O_8 equivalent, down 850,000 pounds since last month. The corresponding figure for **active demand** is **2,545,000** pounds, up 1,545,000 pounds. The spot and near-term **supply-demand ratio** decreased to 1.1 to 1.

The *Current Market Data* section of this Report lists eight natural uranium sales, totaling 1.8 million pounds U_3O_8 equivalent. US-origin uranium is commanding a premium (relative to the Exchange Value) of $2.50 per pound U_3O_8 (up $1.90) in the form of concentrates, and $6.50 per kilogram U (up $4.75) in the form of UF_6.

The **Transaction Value** is **$17.30** per pound U_3O_8, up $0.20 since last month. The calculation extends over a 3-month period and includes 18 transactions involving 3.7 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.50** per kilogram U in UF_6, down $0.25 since last month. Three transactions involving UF_6 are reported, totaling 585,000 pounds equivalent U_3O_8. Demand for UF_6 remains weak, with only two major buyers in the market.

The **Conversion Value** is **$1.90** per pound U as UF_6, up $0.10 since last month. No active supply of secondary market conversion services is reported this month. Active demand totals 440 thousand pounds U as UF_6. Three secondary market conversion transactions are reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Tenth Circuit Court of Appeals has upheld Judge Jim Carrigan's June 1986 ruling in favor of the US uranium producers, ending a year of pronounced uncertainty in the uranium market. Judge Carrigan's original ruling in the US Producers lawsuit against DOE had ordered a 100-percent restriction on the DOE enrichment of non-US-origin uranium for use in US reactors. Some uncertainty remains, however, as DOE has continued to enrich non-US-origin feed material in spite of the Appeals Court decision. DOE has taken the position that the order is not final until the Supreme Court has disposed of the issue, and has filed an emergency motion with the Appeals Court to stay its ruling while DOE prepares a petition for review by the Supreme Court. (The Appeals Court decision and related issues are examined in depth beginning on page 3.)

Immediately following the court decision, at least two US utilities purchased US-origin material. Several other potential buyers appear to be waiting to fill their requirements until further developments in the lawsuit, actions by Congress or a DOE rulemaking clarify the market situation.

As a result of the Appeals Court decision, most US producers immediately withdrew their previous offers, which had been declining in price in recent months, and substantially raised offering prices. Most appear to be offering material in the $22 to $25 range, a substantial increase over the $19 to $20 level prevalent before the decision. The premium (relative to the Exchange Value) for US-origin is $2.50 per pound U_3O_8, up $1.90 since last month. After the premium was introduced in December 1986 ($0.65), it rose steadily to a level of $1.50 in April and May 1987, then began declining. It reached a low point of $0.60 in June. The movement of the premium (its relationship to the Exchange Value) since its first publication is shown in Table 1.

While the Appeals Court's decision is certainly the most important factor influencing the uranium market thus far in 1987, especially in the USA, several important issues remain unresolved:

1. The likelihood and timing of DOE obtaining a stay of the Appeals Court decision are unclear, as is whether DOE's request for a Supreme Court review of the case will be granted.
2. It is unclear whether the 100-percent restriction on DOE's enrichment of non-US-origin has actually become law; if so, DOE will be forced to comply.
3. Judge Carrigan's ruling had earlier ordered DOE to commence a rulemaking proceeding that would establish a (lower) level of import restriction. DOE has not yet begun such a rulemaking. Carrigan retains jurisdiction and any such rulemaking must clearly convince Carrigan that the restriction level sought by DOE is appropriate and meets the intent of the Atomic Energy Act.
4. It is possible (and increasingly likely) that Congress will take action superceding the court-ordered restriction. The timing of such potential action is, however, very unclear at present and the outcome is quite uncertain. Efforts to find a legislative solution will not succeed quickly, as many conflicting interests must be balanced, not the least of which is the Reagan administration's opposition to protectionist legislation.

Outside the USA, the *immediate* impact of the court decision was mitigated by slightly lower prices, enabling the market for *non-US-origin* material to sustain a normal

©NUEXCO 1987

PRICING

Table 1

THE PREMIUM FOR US-ORIGIN U_3O_8
(Relative to the Exchange Value, US$ per pound U_3O_8)

Month (Issue)	Exchange Value	Premium	Premium as Percentage of Exchange Value
December 1986 (220)	$16.75	$0.65	3.9
January 1987 (221)	$16.75	$0.75	4.5
February 1987 (222)	$16.65	$0.85	5.1
March 1987 (223)	$16.75	$1.00	6.0
April 1987 (224)	$17.00	$1.50	8.8
May 1987 (225)	$17.00	$1.50	8.8
June 1987 (226)	$17.00	$0.90	5.3
July 1987 (227)	$16.90	$0.60	3.6
August 1987 (228)	$16.75	$2.50	14.9

amount of activity during July. Thus, the Exchange Value declined $0.15 this month to $16.75 per pound U_3O_8. Two US and two European utilities bought substantial quantities of non-US-origin material for near-term delivery. No long-term sales are reported this month.

The UF_6 Value declined $0.25 to $47.50 per kgU as UF_6. Three transactions involving UF_6 are reported this month, totaling approximately 600,000 pounds U as UF_6. The premium (relative to the UF_6 Value) for US-origin UF_6 increased $4.75, to $6.50 per kgU as UF_6, in conjunction with the increase of the US premium for U_3O_8. Supply of US-origin UF_6 is weak at present. Demand is likewise weak, with only discretionary buyers in the current market.

* * *

The Loan Value remained unchanged this month, at three percent per annum. Two loan transactions are reported, involving approximately 700,000 pounds U_3O_8 equivalent. Although some material is available for loan, little or no demand exists at the present time.

* * *

The Conversion Value rose $0.10 since last month, to $1.90 per pound U in UF_6. Three conversion transactions are reported, totaling about 800,000 pounds U as UF_6; however, the secondary market for conversion services remains relatively inactive. Prices for conversion services in Europe continue to be higher than in the USA. Firm supply currently is lacking in the market, and demand is limited to one potential buyer of conversion services.

ENRICHED URANIUM AND SWU

The SWU Value increased $2.00 this month to $75 per SWU. One SWU transaction is reported in the *Current Market Data* section of the Report. The current SWU Value represents an approximate mid-point in a wide range of prices that characterize the highly segmented secondary SWU market.

At the higher end of the market, Eurodif and Urenco SWU are available at prices several dollars above the current SWU Value, while at the lower end, SWU from other suppliers might be acquired for under $70 per SWU, although additional commercial constraints can raise the effective price to the buyer. If DOE cannot enrich non-US-origin feed material for its US customers, and those customers begin contracting for their enrichment from other sources, there is a potential for further firming of prices for all non-DOE SWU.

At present, near-term SWU demand remains thin, with only one firm buyer in the market for a small quantity of SWU, and another investigating the available options for purchasing in the secondary market.

The market for DOE SWU has become weaker since the Appeals Court ruling upheld Judge Carrigan's decision. In today's market, most of the uncommitted SWU buyers are US utilities, who are understandably concerned over the possibility of a restriction on non-US-origin feed delivered to DOE. Should the Appeals Court decision be upheld, the effective price of enriching acceptable feed at DOE would be substantially higher than it is now. US customers would have to bear the cost of adjusting inventories in order to supply the correct origin, or mix of origins, to DOE for enrichment.

For example, production of 3.5 w/o U_{235} at a tails assay of 0.30 w/o requires about 1.8 kgU of natural UF_6 per SWU. Assuming a 100-percent restriction on non-US-origin feed and the current Nuexco premium for US-origin UF_6 ($6.50 per kgU), the effective cost of DOE SWU to a utility would be $11.70 higher than non-DOE SWU. While there is yet no firm requirement for US-origin feed, in the interim, the uncertainty surrounding DOE's position has acted to depress the price of DOE SWU offered on the secondary market.

©NUEXCO 1987

APPEALS COURT RULES IN US PRODUCERS VS. DOE LAWSUIT

On July 20, 1987, a three-judge panel of the US Court of Appeals for the Tenth Circuit unanimously affirmed US District Court Judge James Carrigan's June 1986 order prohibiting the US Department of Energy (DOE) from enriching any non-US-origin uranium for use in a US reactor (Count I). Count I argued that DOE had violated section 2201(v) of the Atomic Energy Act (as amended in 1964) which required DOE to restrict enrichment of non-US-origin uranium for use in nuclear reactors under US jurisdiction until the viability of the US uranium industry is assured. The Appeals Court also remanded (sent back) to Carrigan's jurisdiction the September 1985 ruling declaring the Utility Services Enrichment Contract (USEC) null and void (Count II). The text of the Appeals Court's decision is reprinted in its entirety beginning on page 7.

Almost immediately after the ruling, DOE filed an emergency motion in the Appeals Court requesting a stay of the decision, pending filing of a petition for *writ of certiorari*, the legal term for requesting that the Supreme Court review the case. If four justices of The Supreme Court voted affirmatively, the Supreme Court would review the case.

Despite the Appeals Court ruling, DOE is still accepting non-US-origin uranium for enrichment and use in US reactors. In doing so, it is arguing that Congress intended DOE to be able to continue enriching non-US-origin uranium until a *final* judgment is rendered by the courts. As a basis for that assertion, DOE cites the bill funding DOE for Fiscal Year 1987, and in particular, language in the Conference Committee Report that describes a final judgment as "a decision by the Court of Appeals '*or the Supreme Court should certiorari be granted*.'"

Market Implications

Under the 100-percent restriction level ordered by the District Court ruling, and upheld on appeal, US utilities would be unable to enrich non-US-origin uranium in their enrichment contracts with DOE until the viability of the US uranium industry is assured. The extent of an *eventual* restriction level (less than 100 percent) is speculative at present, but some intermedate level of restriction is likely to become effective within the next year.

Because of the ruling, some US utilities may be considering backup enrichment suppliers other than DOE if they are to obtain near-term enrichment of their non-US uranium. It is possible that some utilities may have to choose between cancellation of non-US-origin uranium contracts or cancellation of deliveries under DOE enrichment contracts. It may be easier, or less costly, for some US utilities to claim *force majeure* and terminate some SWU deliveries under their DOE contracts, rather than attempt to break uranium supply contracts. The extent and timing of any such cancellations could depend on several factors, such as utilities' individual inventory situations and perceptions about future restriction levels.

Nevertheless, obtaining alternate enrichment supplies may not be economical. Other SWU suppliers might not be competitive at the moment because of the relative weakness of the dollar, and also because of insufficient capacity to meet a surge of new near-term demand. As a result, some utilities are looking at the relative costs of obtaining enriched product with their low-priced non-US-origin uranium and European enrichment versus US-origin uranium and DOE SWU.

For some utilities, swapping the origin of their non-US uranium may be a viable solution under a 100-percent restriction level, to meet feed deliveries under DOE enrichment contracts. The crucial decision may depend on at what price the US-origin can be obtained, relative to the cost of switching to higher-priced enrichment.

To date, the market reaction to the court ruling and the proposed legislation has been cautious. While some US utilities moved quickly and aggressively to acquire US origin uranium, most have elected to wait for the next steps in the court case, whether a DOE stay, a Supreme Court review or a Supreme Court refusal to hear the case. Some observations include the following:

1. DOE appears to have lost the legal battle on the issue of import restrictions. While a final resolution is likely to be delayed by stays and other legal maneuvers, the outcome points toward a complete victory for the US producers on the issue of DOE enrichment of non-US-origin uranium.
2. Unless it is superseded by new legislation or a DOE rulemaking, a 100-percent prohibition on the use of non-US origin uranium will likely be in place for some period of time.
3. The Domenici legislation, in the form currently being discussed (restricting the uranium content in domestic reactors to a maximum of 37.5 percent non-US-origin from 1988 to 1994, and a maximum of 50 percent from 1995 to 2000), faces many of the same obstacles that it did last year, when it was defeated in committee. While Senate passage is possible, House passage is seen as most unlikely, and even were it to pass the House, the Administration remains opposed and a Presidential veto would be likely if it were passed.
4. Wholesale defections by US utilities from their DOE enrichment contracts (in favor of enrichment elsewhere) because of the non-US-origin feed issue are not likely to take place in view of the limited capability of such enrichers to accommodate new customers. Furthermore, it is clear that any attempts by US utilities to abrogate contracts will be vigorously contested by DOE.
5. A 100-percent limitation probably will not be in effect very long. Even the staunchest supporters of the US producers' view recognize that, in the long term, such an extreme

© NUEXCO 1987

position can be maintained only at the risk of drawing a powerful and negative reaction from US utilities, ratepayers and important US trading partners such as Canada and Australia.

6. Since any 100-percent limitation is likely to be of limited duration, US utilities and their non-US suppliers probably will be able to resolve their uranium delivery problems through schedule adjustments and deferrals, as opposed to being forced to breach contracts or going to court.

In view of these perceptions, it is not surprising that US-origin U_3O_8 is commanding higher prices. Both the spot and longer-term markets will be affected. The spot market will reflect the effects of procurement by those buyers with actual needs as well as discretionary buyers looking for bargains. In the longer-term market, floor prices could increase as buyers compete for the uncommitted capacity of current US suppliers, as well as newer suppliers that will require higher prices to begin production.

Background

The suit was filed in December 1984 by three uranium producers — Western Nuclear, Inc., Energy Fuels Nuclear, Inc., and Uranium Resources, Inc. In September 1985, Judge Carrigan ruled in favor of the producers on Count II of the suit, a decision that DOE immediately appealed. Carrigan subsequently ruled on the remaining four counts in June 1986, deciding in favor of the producers with respect to the all-important Count I. DOE then appealed the decision on Count I, and the Appeals Court consolidated the two appeals, hearing arguments in September, 1986. Counts III, IV, and V, covering the Variable Tails Assay Option (VTAO) surcharge, DOE's potential use of the government stockpile, and enforcement of the principle that the US uranium industry should be maintained in a condition whereby it should be capable of supplying 100 percent of US requirements at any time, respectively, were not appealed. An article describing the background of uranium import limitations in the USA generally, and a detailed history of the producers vs. DOE court case can be found on page 13.

Judge Carrigan's June 1986 ruling on Count I ordered that, pending DOE's completion of a rulemaking, DOE "shall restrict its enrichment of source or special nuclear materials of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States" until the viability of the domestic uranium industry is assured. The restriction was to be 75 percent domestic origin from the time of the ruling until January 1, 1987, and 100 percent thereafter. Carrigan's ruling also ordered DOE to commence administrative rulemaking proceedings to establish criteria for providing enrichment services that would comply with the mandate of the Atomic Energy Act.

The criteria to be established by DOE would include a determination of the percentage of non-US-origin material that would be consistent with assuring a viable domestic uranium industry. Carrigan has retained jurisdiction over the issue, and pending the outcome of DOE's appeal procedures the matter would revert to his court. DOE would then have to convince Carrigan that any criteria established with respect to the percent of non-US-origin material would accomplish the mandate of the statute. DOE has thus far refused to conduct such a rulemaking.

The Appeals Court Ruling

In its ruling, the Appeals Court stated that the language of the statute is unambiguous, and that the mandate is clear that DOE "shall" impose such restrictions as are necessary to assure the viability of the domestic uranium industry. The word "shall" in the statute is mandatory, and contrary to DOE's arguments, the additional words of the statute, "to the extent necessary", do not confer on DOE the discretion to decline to impose restrictions based on a DOE contention that restrictions would not be effective in assuring the domestic uranium industry's viability.

> "The DOE's interpretation strains the plain meaning of section 2201(v). The unambiguous language of the statute requires the DOE to refuse enrichment of foreign uranium 'to the extent necessary to assure' a viable domestic industry. The DOE may determine how much restriction is required to assure viability, but it cannot decide not to impose restrictions when the industry is not viable. It must continue to impose restrictions until the domestic industry becomes viable."

The Court noted that DOE's argument that a 100-percent restriction would be ineffective in helping the industry does not alter the plain meaning of the statute, saying "The DOE's argument that this policy is not wise in the present uranium market should be made to Congress and not to the courts. We can only apply the statute as Congress passed it." Finally, the Court relied to a considerable extent on the legislative history surrounding the enactment of the statute, and as evidenced by contemporaneous statements in Congress, that history supports the conclusions of the Tenth Circuit.

On the issue of the USEC (Count II), the Tenth Circuit sent the matter back to Judge Carrigan's court to resolve the question of whether the producers had "standing"; that is, the right to pursue their claims with respect to the USEC. (A party generally has standing if that party can show injury and if the Court can redress that injury by its action.) DOE did not raise the issue of standing at the District Court level, but only upon appeal. The Court of Appeals, however, said that it is required to raise the issue whether or not either party does so. The central issue is whether the adoption of the USEC by DOE caused a decline in demand for domestic uranium. If it did so, the producers were injured, thereby meeting the test for "standing." But the Court apparently was not convinced

© NUEXCO 1987

that the record reflected sufficient causal connection between the USEC and a decreased demand for domestic uranium so as to say that the producers were injured, and thus has remanded that question to Judge Carrigan's court for further findings. Until the issue of standing is resolved, the Appeals Court will refrain from issuing any opinion on the merits of the producers' challenge to the USEC.

Legal Options for DOE and the Producers

After the decision, DOE's main options for continuing to fight the suit included:

1. Petitioning the Appeals Court for a rehearing. Such a petition is intended to set forth points of law or fact that the Court allegedly overlooked or misinterpreted.

2. Filing a motion with the Appeals Court to stay the decision;

3. Petitioning the Supreme Court to review the case on *certiorari*, a necessary preliminary to having the case accepted by the Supreme Court.

Instead of petitioning the Appeals Court for a rehearing, which many observers believed would not be well received by the Court, the Justice Department representing DOE filed an emergency motion in that court, on July 23, to stay the decision pending the filing of a petition for writ of certiorari. If the Court grants the stay (as of press time no action had been taken by the Court), it will be in effect for thirty days, and can be extended beyond that time period at the Appeals Court's discretion. It is highly likely that it will be extended if DOE does file a petition for writ of certiorari. If the Court refuses to stay the decision, the ruling requiring DOE to restrict its enrichment of non-US-origin uranium will go into effect unless DOE seeks a stay from the Supreme Court by way of an application for stay made to Justice Byron White.

In its motion for a stay, DOE set forth arguments as to why the motion should be granted. The arguments were similar to those originally advanced in opposition to Count I, and include:

1. US utilities would be harmed should the court-imposed restrictions be required to go into effect. DOE contends that "the immediate shock of the order in this case falls on utilities that use nuclear fuel." Because many utilities rely on DOE contracts, chiefly the USEC, those utilities may find themselves with "incompatible commitments" for enrichment of their non-US-origin material. DOE estimates that at least $780 million worth of non-US-origin uranium is already contracted for delivery between 1985 and 1990. DOE further stresses that all of the available options — abandoning DOE enrichment contracts for other sources of enrichment of non-US-uranium, or maintaining DOE contracts and buying all US-origin uranium — "will necessarily result in most utilities winding up with duplicative, overlapping, or conflicting contracts for uranium supplies or enrichment services or both."

2. DOE's enrichment business would suffer harm. DOE "faces the prospect of losing hundreds of millions of dollars in enrichment sales, as well as the possibility of being held liable to the utilities for their losses." If utility allegations of breach of contract against DOE are sustained, the utilities might be able to terminate their enrichment contracts with DOE without cost to themselves. According to DOE estimates, up to $500 million in enrichment contracts could be lost in 1988 alone. The main thrust of DOE's argument, however, concerns the impact the ruling could have on DOE's future as an enrichment supplier. Having abandoned DOE for foreign enrichment, there would be considerable incentive to continue using those sources of enrichment services in the future. DOE's motion to stay the decision states that "no court of law will be able to put back together the contracts and commitments that the order in this case has jeopardized."

3. The impact of the ruling on US foreign relations would be harmful, particularly with Canada and Australia. The motion notes that the Department of State and the office of the US Trade Representative had submitted declarations in the case, saying that the District Court order would have "grave consequences" for US trade and diplomatic relations with other countries. Both Canada and Australia had previously sent to the State Department formal notes expressing their countries' concern over the impact of the court order, and both have reiterated their concerns since the Appeals Court decision. They have mentioned that, in their view, an embargo on uranium for the domestic US market puts the USA in breach of its obligations under the General Agreement on Trade and Tariffs (GATT), and as such, the USA could be subject to retaliatory actions and may owe compensation.

Canada's note to the State Department stated that the Court's decision "will severely disrupt Canadian exports..., will upset the broader international market for uranium and will give rise to major trade irritants between the United States and its current suppliers of uranium."

Australia's communique similarly stated that the order "will disrupt the world market for uranium, erode international confidence in the reliability and predictibility of United States policies affecting international cooperation in the peaceful uses of nuclear energy, and give rise to a major problem in trade relations between our countries in that it will impact adversely and unfairly on Australia's exports of uranium to the U.S."

The DOE motion also calls attention to the potential effect on US non-proliferation policy, saying the the USA's ability to be a "consistent, reliable partner" in international nuclear cooperation is a vital element in US foreign relations. In addition, DOE's position as an enrichment supplier is a key link in maintaining US legal controls over uranium, in order to protect against nuclear proliferation. The order "directly

©NUEXCO 1987

'impedes' our ability to control the world-wide spread of nuclear materials."

4. According to DOE, a stay would not cause further harm to the US production industry. DOE's motion for stay says "because any prospect for recreating a viable domestic uranium industry depends on there being a viable nuclear power industry to consume the producers' product, as well as a viable enrichment services provider in the United States to make that product into a usable nuclear fuel, the ultimate interests of miners and millers will, in fact, be undercut by the order in this case."

In its consideration of whether to grant a stay of its decision, the Tenth Circuit Court of Appeals must consider several points:

1. Whether at least four Supreme Court Justices would vote for granting the *writ of certiorari*;
2. the balance of equities, i.e., the respective harm to the parties involved in the suit, the public, etc. in granting or denying the stay; and
3. the likelihood of DOE prevailing in the Supreme Court on the merits of its case.

Essentially, the Circuit Court must consider whether it thinks the case is important enough for the Supreme Court to review. DOE argues that the Court has already acknowledged this to be the case, by the Court having stated in its decision that "This case raises important issues, the resolution of which will affect not only the parties involved in this suit but also all utilities that use nuclear power as well as the eventual consumers who purchase power from such utilities." However, the issues raised are seldom viewed as important constitutional issues with attending social and political implications, which are the types of issues most often considered by the Supreme Court.

If, as many observers expect, the Appeals Court grants the stay, allowing DOE time to file its writ with the Supreme Court, the mandatory restrictions on DOE enrichment probably will not go into effect for some time. The Supreme Court will not review DOE's petition for writ of certiorari before October 1987, when it reconvenes. Thereafter the review process could take several months to a year as the case proceeds through the review process.

Congressional Actions

Although the courts have been the arena for this first phase in the producers' efforts to maintain a viable industry, the real decisionmaking must take place in Congress, as the Appeals Court noted. Since well before the producers' lawsuit was filed, Senator Pete Domenici (R, New Mexico) has been in the forefront of several unsuccessful attempts to enact legislative assistance for the US producers.

A draft of Domenici's recent bill in the Senate would require US nuclear utilities to use fuel with no less that 62.5 percent US-origin uranium content, between 1988 and 1994, and no less than 50 percent from 1995 to 2000. Penalties for non-compliance would be imposed on a sliding-scale basis for those utilities that load less than 62.5 percent US-origin fuel in their reactors. Domenici's proposal has some support from both the US producers and US utilities, and may be part of a larger bill covering enrichment and other uranium-related issues. The section of the bill dealing with import restrictions could, however, ultimately be part of a bill sponsored by Senator Wendell Ford (D, Kentucky) dealing with the conversion of DOE's enrichment enterprise to a government-owned corporation.

A more remote option concerns the possibility of amending or deleting section 161(v) of the Atomic Energy Act. The Domenici legislation would accomplish this. Such an action would render moot the basis of the producers' lawsuit.

Conclusion

Until the judicial, legislative and administrative avenues have run their course, the exact *eventual* degree of restriction on enrichment of non-US-origin uranium for use in reactors in the USA will not be known. It is virtually certain that some partial restriction will ultimately be enacted and enforced.

At present, DOE has petitioned the Appeals Court for a stay of its decision so that DOE (through the Solicitor General) can petition the Supreme Court for a review of the case. After a review, the Supreme Court may accept or decline to hear the case. An eventual decision by the Supreme Court, should the case go that far, could take until some time in 1988 at a minimum. Legislative solutions, such as the one proposed by Senator Domenici, are also highly uncertain. It will be difficult to balance the several opposing interests, such as those of the uranium producers, the electric utilities, and the administration, in a bill that can be passed by Congress. The court-ordered DOE rulemaking, which DOE has not yet started, also could establish a level of import restriction that might be acceptable to the affected parties.

US utilities must consider how to plan both for a possible immediate 100-percent restriction level, the duration of which is unknown, and for a likely, but also uncertain, less-than 100-percent restriction at some future date. In such a planning, several alternatives are possible, ranging from abrogating existing DOE contracts and looking for overseas enrichment to maintaining DOE enrichment and possibly buying additional US-origin uranium to comply with some yet-unknown US-origin requirement.

Restrictions on imports of uranium into the USA also will affect both US and non-US uranium producers. Both must weigh the potential impact of several possible restricted market scenarios on their pricing strategies, production plans, and contract obligations. Until these uncertainties are reduced, uranium producers and utilities will continue to find it difficult to make firm plans for the future.

© NUEXCO 1987

UNITED STATES COURT OF APPEALS FOR THE TENTH CIRCUIT

Nos. 85-2428
86-1942

WESTERN NUCLEAR, INC., ET AL.,

Plaintiffs,

v.

F. CLARK HUFFMAN, ET AL.,

Defendants- Appellants.

APPEAL FROM THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF COLORADO
(D.C. No. 84-C-2315)

Before McKAY, McWILLIAMS AND BALDOCK, Circuit Judges.

McKAY, Circuit Judge.

Plaintiffs, three uranium mining and milling companies, filed a five-count complaint challenging various Department of Energy (DOE) policies. Shortly after filing the complaint, plaintiffs moved for summary judgment on count two, which challenged the DOE's use of the recently adopted uranium enrichment services contract (UESC). The district court granted plaintiffs' motion, and the DOE appealed. While that appeal was pending, the district court also granted plaintiffs' summary judgment motion on count four (Editor's note: this was actually count one), which alleged that the DOE was statutorily required to restrict enrichment of foreign uranium. The DOE appealed that decision, and we consolidated the two appeals.

This case raises important issues, the resolution of which will affect not only the parties involved in this suit but also all utilities that use nuclear power as well as the eventual consumers who purchase power from such utilities. A brief exposition of the nuclear industry and its history is helpful in understanding these important issues and their ramifications.

I. Background

Private-entity involvement in the nuclear industry evolved gradually. In its infancy, the Government had a complete monopoly over the nuclear industry. It owned all uranium, all nuclear fuel, and all nuclear production and utilization facilities. Initially, the Atomic Energy Commission (AEC), the DOE's predecessor, controlled these operations. The AEC did permit private entities to mine uranium ore, but these entities could only sell to the Government. In 1954, Congress enacted legislation that permitted private ownership of nuclear reactors as well as private possession and use, but not ownership, of nuclear fuel. The AEC issued licenses permitting use of nuclear fuel and monitored entities that owned reactors and used nuclear fuel. However, private entities that mined uranium ore continued to have only one customer — the Federal Government. Finally, in 1964, Congress passed legislation permitting private ownership of nuclear fuel and allowing uranium mining and milling companies to sell to private entities.

Notwithstanding this shift to the private sector, the Government continued to play an important role in the nuclear fuel cycle. The natural uranium mined could not be used directly as nuclear fuel by the private entities that bought it. Natural uranium consists of less than one percent U-235, and nuclear fuel must contain approximately three percent U-235. Thus, to be used as nuclear fuel, uranium must have a higher concentration of U-235 than is found in nature. The process that produces this high concentration is called "enrichment," and, in 1964, the AEC was the only entity in the world with enrichment facilities. Consequently, private entities could not use natural uranium unless the AEC first enriched it to the level required for use as nuclear fuel. Congress recognized this and, when it privatized the ownership of nuclear fuel, permitted the AEC to contract with private entities for the provision of enrichment services. In order to protect the economic strength of the domestic uranium industry, Congress also restricted enrichment of foreign uranium when the resulting nuclear fuel was designated for use in domestic facilities. Initially, the AEC was not permitted to enrich any foreign uranium for domestic use. As demand for nuclear fuel increased, however, the restrictions were phased out, and the AEC, later the DOE, eventually provided enrichment services for both domestic and foreign uranium.

Increases in demand for nuclear fuel also encouraged foreign entities to build enrichment facilities. This increased the competition for enrichment and permitted some of the DOE's domestic and foreign customers to obtain enrichment services outside the United States. As long as demand for nuclear fuel continued to increase, neither the DOE nor the domestic mining and milling companies were overly concerned with foreign competition. Rather, they were operating at capacity and were not threatened by the foreign competition.

The boom, however, was followed by a bust. Private entities that expected uranium demand to exceed supply had entered long-term contracts for uranium and for enrichment services. The quantities were based on forecasts of nuclear fuel needs in all present and future facilities. Unfortunately, many nuclear facilities were not completed on schedule, or were never completed, and private entities were left with huge stockpiles of nuclear fuel and no place to use it. Some sold nuclear fuel to other entities and, as their contracts expired,stopped purchasing both uranium and nuclear fuel. Others, however, began to purchase higher quality uranium at lower costs from now fully operational foreign mines.

The DOE also faced increased foreign competition in the enrichment field. It responded by offering enrichment services on new and different terms. Restrictions on enrichment of foreign uranium had long since been discontinued, but the DOE

©NUEXCO 1987

now offered a variable-tails option in order to attract customers away from the foreign competition. Tails are the depleted uranium left over after the enrichment process is completed. A DOE customer could select a low tails assay — a low concentration of U-235 in the tails — and decrease the uranium required in the enrichment process. In other words, by increasing the enrichment used on a particular quantity of uranium, the DOE was able to increase the amount of enriched uranium produced from a given quantity of natural uranium. By offering the variable-tails option, the DOE permitted its customers to use more uranium and less enrichment services or less uranium and more enrichment services.

These DOE policies with respect to enriching foreign uranium and offering a variable-tails option increased the perceived economic threat to domestic uranium mining and milling companies. They faced increased use of foreign uranium as well as decreased use of uranium in general because of the new variable-tails option. Plaintiffs and other mining and milling companies responded by requesting that the DOE implement restrictions on enrichment of foreign uranium as required by 42 U.S.C. section 2201(v) (1982), which provides that the DOE, "to the extent necessary to assure the maintenance of a viable domestic uranium industry shall not offer (enrichment) services for source or special nuclear materials of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States." The DOE initially refused, claiming that the domestic mining and milling industry was viable, and, thus, section 2201(v) did not require any restrictions. In 1984 and again in 1985, however, the DOE expressly found that the domestic uranium industry was not viable. Even so, it still refused to impose restrictions, now claiming that even if restrictions were imposed the domestic industry would not become viable.

Meanwhile, the DOE was grappling with economic problems of its own. It had become the high cost provider of enrichment services and had lost many of its customers to foreign enrichers. In an attempt to recapture part of the market, the DOE adopted the UESC. This standard form contract provided lower prices, encouraged use of foreign source uranium, and permitted a variable-tails option. Prior to using the UESC, the DOE did not implement any rulemaking procedures pursuant to the Administrative Procedure Act or submit the contract to Congress.

Plaintiffs, already threatened by the precarious economic state of the uranium industry, felt further threatened by the UESC and thereafter filed their complaint in this matter.

II. Challenge to Uranium Enrichment Services Contract

In count two of their complaint, plaintiffs challenged the DOE's adoption of the UESC. The claim was based on both substantive and procedural grounds, but the district court reached only the latter in concluding that the adoption of the UESC was procedurally defective. It stated:

> I conclude that the new (UESC) amounts to a change in the "criteria" under which enrichment services are to be performed. Because the contract was not submitted to Congress, it is null and void.
>
> Accordingly, it is ordered that the plaintiffs' motion for partial summary judgment as to Count II is granted.

Amended Order, record, vol. 2, doc. 15, at 4.

The DOE now challenges the decision on count two, claiming that: (1) plaintiffs' claim is moot; (2) plaintiffs' lack standing; and (3) the district court was erroneous on the merits.

A. Mootness

Mootness goes to the jurisdiction of a federal court. To satisfy the "case or controversy" limitation of Article III, "[t]he actual controversy between the parties 'must exist at stages of appellate or certiorari review, and not simply at the date the action is initiated.'" *Wiley*, 612 F.2d at 475 (quoting *Roe v. Wade*, 410 U.S. 113, 125 [1973]). "Simply stated, a case is moot when the issues presented are no longer 'live' or the parties lack a legally cognizable interest in the outcome." *Powell v. McCormack*, 395 U.S. 486, 496 (1969). *County of Los Angeles v. Davis*, 440 U.S. 625, 631 (1979) (quoting *United States v. W.T. Grant Co.*, 345 U.S. 629, 632-33 (1953)), and can be satisfied only if two conditions are shown:

> (1) it can be said with assurance that "there is no reasonable expectation ..." that the alleged violation will recur, see [*W.T. Grant*, 345 U.S.] at 633; see also *SEC v. Medical Committee For Human Rights*, 404 U.S. 403 (1972), and
>
> (2) interim relief or events have completely and irrevocably eradicated the effects of the alleged violation. See, *e.g.*, *DeFunis v. Odegaard*, 416 U.S. 312 (1974); *Indiana Employment Security Div. v. Burney*, 409 U.S. 540 (1973).

Davis, 440 U.S. at 631.

We need only reach the second condition. The DOE asserts that plaintiffs' sole challenge to the UESC was that its implementation was procedurally defective. Indeed, the grounds for the district court's granting of plaintiffs' summary judgment motion was that "the [UESC] amounts to a change in the 'criteria' under which enrichment services are to be performed [and it] was not submitted to Congress." *Western Nuclear, Inc. v. Huffman*, No. 84-C-2315, slip op. at 4 (D. Colo. Sept. 19, 1985). Since the district court's decision in this case, the DOE has submitted the UESC to rulemaking procedures. DOE, therefore, argues that plaintiffs' appeal is moot.

We need not determine whether subsequent DOE and congressional activity cured any alleged procedural defects in this case and thus mooted plaintiffs' claim. Their challenge was not based only on procedural grounds; it included substantive grounds as well, and plaintiffs' substantive challenge to the UESC remains viable. The DOE admits that the criteria adopted through the subsequent rulemaking procedures are the same as those embodied in the UESC. Consequently, if substantive deficiencies existed before the DOE rulemaking process, they still exist.

Because we conclude that the DOE has not shown that plaintiffs' claim has been eradicated by subsequent rulemaking, we need not reach the issue of whether the violations can recur. The DOE has filed to show that plaintiffs' claim is moot.

© NUEXCO 1987

B. Standing

Even though the DOE did not challenge plaintiffs' standing in the district court, we must address that issue before we can reach the merits of this case.

> Federal courts are not courts of general jurisdiction; they have only the power that is authorized by Article III of the Constitution and the statutes enacted by Congress pursuant thereto. *See, e.g., Marbury v. Madison*, 1 Cranch (5 U.S.) 137, 173-180, 2 L.Ed. 60 (1803). For that reason, every federal appellate court has a special obligation to "satisfy itself not only of its own jurisdiction, but also that of the lower courts in a cause under review," even though the parties are prepared to concede it. *Mitchell v. Maurer*, 293 U.S. 237, 244, 55 S. Ct. 162, 165, 79 L.Ed. 338 (1934).

Bender v. Williamsport Area School Dist., 106 S. Ct. 1326, 1331 (1986). One jurisdictional requirement is that of standing.

Standing focuses on whether a particular plaintiff has the right to pursue a cause of action. "[L]ike mootness and ripeness, [it] 'has its constitutional origins in the "case or controversy" limitation of Article III which insures that courts exercise their power only in cases where true adversary context allows informed judicial resolution.'" *Citizens Concerned for Separation of Church & State v. City of Denver*, 628 F.2d 1289, 1294 (10th Cir. 1980) (quoting *Wiley v. National Collegiate Athletic Ass'n*, 612 F.2d 473, 475 (10th Cir. 1979), *cert. denied*, 446 U.S. 943 (1980)), *cert. denied*, 452, U.S. 963 (1981). While the courts have not always been clear as to which standing requirements are based on the Constitution and which are based on prudential concerns of the courts, they have established that:

> at an irreducible minimum, Art. III requires the party who invokes the court's authority to "show that he personally has suffered some actual or threatened injury as a result of the putatively illegal conduct of the defendant," *Gladstone, Realtors v. Village of Bellwood*, 441 U.S. 91, 99 (1979), and that the injury "fairly can be traced to the challenged action" and "is likely to be redressed by a favorable decision," *Simon v. Eastern Kentucky Welfare Rights Org.*, 426 U.S. 26, 38, 41 (1976).

Valley Forge Christian College v. Americans United for Separation of Church & State, Inc., 454 U.S. 464, 472 (1982). Consequently, to establish standing plaintiffs must show[1] that the DOE's adoption of the UESC has injured them and that the court can redress that injury by invalidating the UESC.

Plaintiffs claim they have met this burden because the DOE, by filing its cross-motion for summary judgment without challenging standing, implicitly acknowledged plaintiffs' standing. However, "[p]arties may not by stipulation invoke judicial power of the United States in litigation which does not present an actual case or controversy, and jurisdictional questions are of primary consideration and can be raised at any time by courts on their own motion." *City of Denver*, 628 F.2d at 1296-97 (citations omitted). Thus, the DOE cannot consent to plaintiffs' standing. In fact, even if no party challenged standing, we are required to raise the issue.

At the summary judgment stage, plaintiffs are entitled to prevail only if the record shows "that there is no genuine issue as to any material fact and that [plaintiffs are] entitled to a judgment as a matter of law." Fed. R. Civ. P. 56(c). When the standing issue is not raised in the district court, review on appeal may reveal factual disputes. *See, e.g., Steele v. National Firearms Act Branch*, 755 F.2d 1410, 1414 (11th Cir. 1985)

The factual dispute with respect to standing in this case revolves around the causation element of standing. The parties agree that plaintiffs have been harmed by the decline in demand for domestic uranium; however, they disagree on whether the adoption of the UESC has any nexus to that decline. An affidavit filed by plaintiffs in support of their motion for summary judgment states in relevant part:

> DOE policies with respect to the provision of enrichment services can have and do have a significant impact on demand for uranium and, consequently, the viability of the domestic uranium industry. For example, independent consultants (*e.g.*, Nuexco and Nuclear Resources International) indicate that DOE's new [UESC] may diminish demand for uranium by as much as 100,000,000 pounds or more over the next five to ten years. This approximates or exceeds expected production for the period.

Plaintiff's Memorandum in Support of Motion for Summary Judgment on Count II, record, vol. 1, doc. 3, Exhibit B (affidavit of Larry A. Boggs), at paragraph 2. To support the causal link, and thus standing, between the adoption of the UESC and the decrease in demand for domestic uranium, plaintiffs argue on appeal that the UESC: (1) fails to restrict enrichment of foreign uranium; (2) permits enrichment customers to select a variable-tail assay that increases the use of enrichment services and decreases the use of uranium; and (3) contains pricing provisions that decrease demand for domestic uranium. If the UESC is invalidated, plaintiffs argue, these policies will be reversed and the demand for domestic uranium will consequently increase. However, since standing was not challenged in the district court, the record fails to explain how the UESC would decrease demand for domestic uranium and thereby cause plaintiffs harm. Plaintiffs' claim that we may look beyond the record to the circumstances surrounding the case is inaccurate. The Supreme Court has specifically stated that "[t]he existence of a justifiable 'case' or 'controversy' under Art. III must affirmatively appear in the record." *Bender*, 106 S. Ct. at 1334.

Notwithstanding DOE's failure to challenge plaintiffs' standing at the trial level, it did specifically refute plaintiffs' claim that the UESC harmed them because it decreased demand for domestic uranium. The DOE claimed in that forum that the UESC did not amend existing DOE policy and, thus, could not change the demand for domestic uranium. On this appeal, the DOE renews this contention by arguing that even though the demand for domestic uranium has declined and will likely continue to

---

[1] Plaintiffs bear the burden of proving standing. This "burden is not insurmountable; they need only demonstrate a 'substantial liklihood' that the causal link exists," *Munoz-Mendoze v. Pierce*, 711 F.2d 421 (1st Cir. 1983), and "that the relief requested will redress the injury." *Duke Power Co. v. Carolina Envtl. Study Group, Inc.*, 438 U.S. 59, 75 n.20 (1978).

© NUEXCO 1987

decline, the adoption of the UESC did not affect that demand and, consequently, plaintiffs do not have standing to challenge the UESC. It maintains that the policies behind the UESC existed prior to its adoption and would continue to exist even if the UESC were declared null and void.

Plaintiffs conceded in their complaint that the DOE did not restrict enrichment of foreign uranium and allowed customers to select a variable-tail assay before the adoption of the UESC. *See* Complaint, record, vol. 1, doc. 1 at 9, 17, 18. An injury that "occurred before, existed at the time of, and continued unchanged after the challenged" action cannot support a standing claim. *California Ass'n of the Physically Handicapped, Inc. v. FCC*, 778 F.2d 823 (D.C. Cir. 1985). Policies ostensibly harming plaintiffs that existed prior to the adoption of the UESC are insufficient to vest plaintiffs with standing to challenge the legality of the UESC. However, the record in this case is unclear as to whether adoption of the UESC did in fact effect a change in DOE policies regarding enrichment of foreign uranium and availability of variable-tail assays. The UESC may have implemented more lenient policies that exacerbated the economic harm already experienced by plaintiffs. This unresolved factual dispute surrounding the causation component of the standing inquiry may not be resolved on appeal.

Plaintiffs argue alternatively that UESC pricing of DOE enrichment services may decrease demand for domestic uranium, thus harming them and supporting standing to challenge the UESC. Plaintiffs cannot argue that lower enrichment prices decrease domestic uranium sales. If the DOE has higher prices, DOE customers are encouraged to seek enrichment services from DOE's foreign competitors. Both parties agree that entities who use foreign enrichers also tend to purchase foreign uranium. Consequently, a decrease in DOE enrichment prices should encourage domestic enrichment and, concomitantly, domestic uranium purchases. On the other hand, plaintiffs may be arguing that new pricing techniques favor foreign uranium over domestic uranium and, thus, decrease demand for domestic uranium. We find this doubtful because section 2201(v) specifically mandates that pricing of enrichment services be nondiscriminatory. Nonetheless, plaintiffs should be permitted to present whatever factual support they have for this argument on remand.

Because of the unresolved factual dispute surrounding the causation component of the standing inquiry, we cannot conclude that plaintiffs have satisfied their burden on appeal of establishing standing. However, because the DOE failed to contest standing in the district court, plaintiffs should be allowed to present evidence supporting their standing allegations. "Factual issues concerning the existence of the standing requirements in a particular case are to be resolved in the same manner as any other controverted fact." *Steele*, 755 F.2d at 1414. Thus, we remand for resolution of the factual dispute which will be determinative of plaintiffs' standing to challenge the UESC.

C. Merits

Because the issue of standing on this claim remains unresolved, any opinion on the merits of this case would be an advisory opinion. "[F]ederal courts established pursuant to Article III of the Constitution do not render advisory opinions." *United Pub. Workers of Am. v. Mitchell*, 330 U.S. 75, 89 (1947). Thus, we cannot reach the merits of plaintiffs' challenge to the UESC.

III. Restrictions on Enrichment of Foreign Uranium

Count four of plaintiffs' complaint alleges that the DOE violated 42 U.S.C. section 2201 (v) (1982) when it refused to restrict enrichment of foreign uranium despite a determination that the domestic uranium industry was not viable. The DOE argues that restrictions are only required if they would make the domestic uranium industry viable and that restrictions at this time would not result in a viable industry. The district court interpreted section 2201 (v) to require the DOE to restrict enrichment of foreign uranium whenever the domestic industry is not viable — whether or not such restriction would result in successful resuscitation of the uranium industry. The DOE appealed and moved to stay enforcement of the district court order until the appeal was finally decided. We granted the motion to stay and expedited the appeal.

This case is one of statutory interpretation. The parties agree that the domestic uranium industry is not viable and agree that the DOE's actions are controlled by section 2201 (v). However, they disagree on the meaning of that statute. Even under current law, which requires great deference to agency interpretation of statutes, the Supreme Court has recognized that:

> [t]he judiciary is the final authority on issues of statutory construction and must reject administrative constructions which are contrary to clear congressional intent. If a court, employing traditional tools of statutory construction, ascertains that Congress had an intention on the precise question at issue, that intention is the law and must be given effect.

Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc., 467 U.S. 837, 843 n.9 (1984) (citations omitted). Under this authority, the district court decided that, unless the DOE determines that something other than restrictions will assure the viability of the domestic uranium industry, section 2201(v) requires restrictions on enrichment of foreign uranium whenever the domestic industry is not viable. Since this is a statutory interpretation question, we review that decision *de novo*. *See Supre v. Ricketts*, 792 F.2d 958, 961 (10th Cir. 1986); *City of Edmonds v. United States Dep't of Labor*, 749 F.2d 1419, 1421 n.2 (9th Cir. 1984).

The courts have long recognized that "the starting point for interpreting a statute is the language of the statute itself." *Consumer Prod. Safety Comm'n v. GTE Sylvania, Inc.*, 447 U.S. 102, 108 (1980); *see also Rubin v. United States*, 449 U.S. 424, 429 (1981). "When we find the terms of a statute unambiguous, judicial inquiry is complete, except 'in "rare and exceptional circumstances."'" *Id.* at 430 (quoting *TVA v. Hill*, 437 U.S. 153, 187 n.33 (1978) (quoting *Crooks v. Harrelson*, 282 U.S. 55, 60 (1930)) Even when an agency interpretation is normally entitled to deference, "[i]f the intent of Congress is clear, that is the end of the matter; for the court, as well as the agency, must give effect to the unambiguously expressed intent of Congress." *Chevron U.S.A.*, 476 U.S. at 842-43. Thus, we look first to the language of the statute, and if it is unambiguous, we look to the legislative history only to determine if exceptional circumstances dictate an interpretation contrary to the language of the statute.

As noted, the relevant portion of the statute provides that "*to the extent necessary to assure the maintenance of a viable domestic uranium industry, [the DOE] shall not offer*" enrichment services for foreign-source uranium designated for use in the United States. 42 U.S.C. section 2201(v) (emphasis added). The DOE relies on *Young v. Community Nutrition Institute*, 106 S. Ct. 2360 (1986), in arguing that the phrase "to the extent necessary" gives it discretion to determine whether to restrict enrichment of foreign uranium. The Supreme Court in *Young* was interpreting 21 U.S.C. section 346 (1982), which states:

> Any poisonous or deleterious substance added to any food, except where such substance is required in the production thereof or cannot be avoided by good purposes of the application of clause (2) (A) of section 342(a) of this title; but when such substance is so required or cannot be avoided, the Secretary shall promulgate regulations limiting the quantity therein or thereon *to such extent as he find necessary for the protecting of public health*, and any quantity exceeding the limits so fixed shall also be deemed to be unsafe for purposes of the application of clause (2) (A) of section 342(a) of this title. (Emphasis added.)

The FDA's longstanding interpretation was that the phrase "to such extent as he finds necessary for the protection of public health" modified the word "shall". Thus, the FDA was of the opinion that it was to determine when regulation was necessary to protect public health. Having determined that regulating aflatoxin (a poisonous substance present in some foods) was not necessary to protect the public health, the FDA did not promulgate regulations. The Supreme Court decided that it was unclear whether the critical phrase modified "shall" or "the quantity therein or thereon." As a result, the Supreme Court concluded that the courts should adopt the agency interpretation of the statute as a reasonable one. The critical point in the analysis was that the "FDA [had] advanced an interpretation of an ambiguous statutory provision." *Young*, 106 S. Ct. 2365. Once that point was reached, the Court was required to defer to the reasonable interpretation of the agency.

The case before us presents a different situation. Congress, in enacting section 2201(v), used unambiguous language. It stated "the [DOE] . . . shall not offer" the enrichment of foreign uranium. The use of "shall" is usually mandatory language and will require action unless a convincing argument to the contrary can be made. *See City of Edmonds*, 749 F.2d at 1421; *American Fed'n of Gov't Employees v. Federal Labor Relations Auth.*, 739 F.2d 87, 89 (2d Cir. 1984); *Manatee County v. Train*, 583 F.2d 179, 182 (5th Cir. 1978); *Association of Am. R.R. v. Costle*, 562 F.2d 1310, 1312 (D.C. Cir. 1977). Thus, section 2201(v) requires that the DOE not offer enrichment of foreign uranium.

This requirement is, of course, subject to the modifying phrase "to the extent necessary to assure the maintenance of a viable domestic uranium industry." That phrase, however, is also unambiguous. It informs the DOE of the *amount* of restriction required, it does not provide a scenario in which the DOE is excused from restricting foreign enrichment notwithstanding a nonviable domestic industry. It instructs that when domestic nonviability is determined, restrictions on enrichment of foreign-source uranium must be imposed and must become increasingly aggressive, to the point of 100% restriction, until the domestic industry is rejuvenated and becomes viable. If a less-than-100% restriction can assure viability, only that lesser level of restriction is required. The statute does not provide that increasingly stiffer restriction are required only to the point that DOE determines that such restrictions will not resuscitate the industry. Under its interpretation of the statue, the DOE has no discretion until that time, but once such a determination is made, it may lift *all* restrictions — at the precise point in time when the domestic industry is at its lowest ebb.

Furthermore, the nature of the modifying phrase here differs from *Young*. In *Young*, the FDA specifically argued that regulations were not required to protect the public health; rather, tolerance levels established by the FDA accomplished that goal. The FDA credibly argued that it could serve the statutory purpose — the protection of the public health — without publishing regulations for aflatoxin. In this case, the DOE cannot accomplish its statutory purpose — the maintenance of a viable domestic uranium industry — without imposing restrictions on enrichment of foreign uranium. Rather the DOE proposes to abandon the statutory goal. The DOE does not argue that the domestic industry is viable without restrictions; it claims that it has discretion to determine whether to implement restrictions when restriction will not assure the viability of the domestic industry. The DOE's interpretation strains the plain meaning of section 2201(v). The unambiguous language of the statute requires the DOE to refuse enrichment of foreign uranium "to the extent necessary to assure" a viable domestic industry. The DOE may determine how much restriction is required to assure viability, but it cannot decide not to impose restrictions when the industry is not viable. It must continue to increase restrictions until the domestic industry becomes viable. The DOE's argument that this policy is not wise in the present uranium market should be made to Congress and not to the courts. We can only apply the statute as Congress passed it.

Finally, this is not a "rare and exceptional" case in which the language of the statute must give way to clear congressional intent. In hearings prior to the enactment of section 2201(v), consistent concern was expressed over the effects of imports on the domestic uranium industry. *See, e.g., Private Ownership of Special Nuclear Materials: Hearing Before the Subcomm. on Legislation of the Joint Comm. on Atomic Energy*, 88th Cong., 1st Sess. 114-15 (1963) (Statement of Richard D. Bokum II, President, United Nuclear Corp.); *id.* at 145 (statement of Andrew J. Biemiller, Director, Department of Legislation, AFL-CIO); *Private Ownership of Special Nuclear Materials, 1964: Hearings Before the Subcomm. on Legislation of the Joint*

©NUEXCO 1987

Comm. on Atomic Energy, 88th Cong., 2d Sess. 154 (1964) (statement of Dean A. McGee, President, Kerr-McGee Oil Industries). In its report to Congress, the Joint Committee first recognized the importance of a viable domestic uranium industry:

> The maintenance of a viable domestic uranium mining and milling industry is an essential part of a sound nuclear industry and is also vital to the long-range defense and security interests of the United States. The bill accompanying this report, by providing for uranium enrichment services, is a desirable step in this direction.

S. Rep. No. 1325, 88th Cong., 2d Sess., *reprinted in* 1964 U.S. Code Cong. & Admin. News 3105, 3115. The committee then explained the basis for requiring restrictions.

> [I]mportation could have a serious impact on the uranium mining and milling industry, particularly during a period of limited demand for its product. Accordingly, the flexible restriction contained in the committee bill will allow the [DOE] to review periodically the condition of the domestic and world uranium markets and to offer enrichment services on a basis which will assure, in its opinion, the maintenance of a viable domestic uranium mining and milling industry.
>
> ...[T]he committee...has concluded that it would be reasonable to place restrictions upon the performance of services by the [DOE] where the enrichment of foreign material would have an adverse effect on the domestic uranium industry. It is the committee's view that the measures taken in this bill to assure the viability of the domestic uranium industry are in the national interest since this industry is closely related to our vital defense and security interests.

Id., reprinted in, 1964 U.S. Code Cong. & Admin. News at 3120-21. At no point in the legislative history is there any indication that Congress would permit the DOE to abandon attempts to maintain a healthy domestic industry. On the contrary, Congress considered a viable domestic industry to be vitally important to United States' defense and security interests and did not want the United States to become dependent on foreign sources of uranium. We conclude that the legislative history supports our determination that if the domestic uranium industry is not viable, the DOE must restrict enrichment of foreign uranium. Thus, we affirm the district court's decision granting plaintiffs' summary judgment motion on count four.

III. Conclusion

Plaintiffs' challenge to the UESC is remanded to the district court. The record does not clearly demonstrate that plaintiffs have standing. However, the DOE did not challenge standing in the district court, and plaintiffs should be given an opportunity to prove their standing allegations.

Plaintiffs' claim that section 2201(v) unambiguously requires the DOE to implement restrictions on enrichment of foreign uranium when the domestic uranium industry is not viable is correct. The DOE has not implemented such restrictions and, thus, the district court's decision granting plaintiffs injunctive relief was appropriate and should be affirmed.

The case is affirmed in part and remanded in part, with instructions to proceed in a manner consistent with this opinion. The stay of the district court's injunction heretofore entered is dissolved.

© NUEXCO 1987

HISTORY OF THE URANIUM PRODUCERS VS. DOE LAWSUIT

Introduction

On July 20, 1987, The US Court of Appeals for the Tenth Circuit issued its decision upholding Judge Carrigan's June 1986 ruling in the lawsuit brought by three US uranium producers against DOE. The appeal concerned Counts I and II of the original five-count suit; the other counts had been resolved earlier. Count I sought to force DOE to limit the enrichment of non-US-origin uranium feed material, so as to ensure a viable US uranium industry, as called for under an amendment to the Atomic Energy Act of 1954. Count II sought to declare the Utility Services Enrichment Contract (USEC) null and void. The Appellate Court's decision affirmed the earlier decision on Count I, and remanded Count II back to the District Court for further consideration, noting that the plaintiffs' (the producers') "standing" was still in question.

Background

The position of the three plaintiffs in the lawsuit against DOE is primarily based on amendments to the Atomic Energy Act of 1954. The Act [Section 161(v)] provides that enrichment of non-US origin uranium for use in US facilities shall be limited so "as to assure the maintenance of a viable domestic industry." The Act has been used earlier to limit uranium imports into the USA, and so provides a precedent for the producers' legal action. Prior to 1974, this language was interpreted by the US Atomic Energy Commission (AEC) as prohibiting *any* enrichment of non-US origin material for domestic end use.

However, on November 27, 1973, the AEC published in the Federal Register notice of its intent to relax and eventually eliminate this prohibition. The following table outlines the AEC's timetable for accomplishing this phasing out of the limitation:

Calendar Year	Percentage of Enrichment Customer's Feed Which May Be of Non-US Origin
1977	10
1978	15
1979	20
1980	30
1981	40
1982	60
1983	80
1984 and beyond	100

This proposal was not finally adopted until October 25, 1974. In order to assure a viable domestic uranium production industry, the AEC announced that it would monitor US utility purchases of non-US origin material with a view toward

A Brief Chronology of the Lawsuit

1984	December	Three US uranium producers file lawsuit in US Tenth District Court.
1985	June	Uranium Producers of America (UPA) formed.
	September	Carrigan rules on Count II of lawsuit.
		DOE announces that US uranium industry is non-viable for 1984.
1986	January	DOE proposes new enrichment criteria.
	June	Carrigan rules on Counts I, III, IV and V.
		DOE files motion for stay of the ruling.
		Producers drop Count V.
	July	US Tenth Circuit Court of Appeals grants DOE a stay pending appeal.
		DOE submits final enrichment criteria wording to Congress.
	August	House/Senate joint resolution partially approves criteria.
	September	Appeals Court panel hears arguments on Counts I and II of lawsuit.
	November	DOE declares US uranium industry non-viable for 1985.
1987	July	US Tenth Circuit Court of Appeals rules on appeal of lawsuit.

© NUEXCO 1987

preventing domestic overdependence on foreign sources of supply. The AEC considered the possibility of reimposing any partial or total embargo as remote, and the utilities were assured that if such a reimposition were deemed necessary, it would not affect agreements entered into prior to a reimposition.

The AEC's decision in 1974 to phase out the embargo was based on the prevailing perception that the rate of nuclear generating growth and associated uranium demand was capable of supporting a thriving domestic uranium industry, as well as absorbing a considerable volume of imported material. In 1974, most sources estimated US uranium requirements for 1985 to be nearly 100 million pounds U_3O_8. Actual US requirements for 1985 amounted to only about 30 million pounds.

During the period from 1974 until 1979, few complaints were voiced about the US policies regarding uranium imports. However, in late 1979, following the Three Mile Island accident and the onset of a rash of nuclear plant cancellations, uranium prices began to drop.

Prior to the lawsuit, the struggling US uranium industry had begun to focus its attention on legislative attempts to limit US utility use of non-US-origin uranium. The first attempt occurred in the fall of 1980 when Senator Domenici (R, New Mexico) attempted to attach an amendment to DOE's 1981 appropriations bill. The amendment was deleted from the bill when requisite support failed to materialize (see Report 146, October 1980).

Senator Domenici tried again in March 1982 when he proposed the requirement that 80 percent of the uranium used by US reactors must be of US origin. This attempt also failed, and the pro-embargo forces achieved neither their original 20-percent limit nor a compromise 37.5-percent limit on imports of non-US-origin uranium.

In 1983, legislation was enacted that provided for studies, reports, and avenues for action in the event uranium imports exceeded or were expected to exceed 37.5 percent in any two consecutive year period. While most US producers regarded this legislation to be a victory at the time, it ultimately provided them little relief. Principally because of the Reagan administration's emphasis on free trade and reluctance to support embargo initiatives of any type, the legislation had little influence on US uranium import policies.

The Utility Services Enrichment Contract (USEC)

Since 1982, DOE had been experimenting with replacing the Adjustable Fixed-Commitment Contract with other types of contracts. In 1983, DOE introduced the Interim Sales Contract and later, the Modified Interim Sales Contract, to counter terminations by 3.5-year Requirements Contract holders. In December 1983, DOE presented drafts of a new "Requirements Contract" to utility executives. This became the Utility Services Enrichment Contract (USEC). In January 1984, DOE released a final draft USEC that included the following items:

1. Customers had to *agree* to convert to the new USEC by October 1, 1984.
2. Adjustable Fixed-Commitment Contract (AFC) holders could reduce their Fiscal Year 1985 and 1986 SWU requirements by 10 and 25 percent, respectively.
3. Requirements contract holders could convert and *immediately* begin taking only 70 percent of requirements from DOE.
4. The lead time for changing the commitment percentage was reduced to five years.
5. Termination charges were reduced to zero upon 10 years' advance notice.
6. Requirements above the minimum commitment could be purchased from any source beginning in FY87.

In this context the USEC, a requirements-type contract which reduces and defers uranium demand, became the final affront to uranium industry expectations. In addition, a surcharge was added making tails assays above 0.20 w/o U_{235} less attractive and, as the result of individual negotiation, a number of utilities gained the right to utilize existing inventories of enriched product, further reducing and delaying the need for new supplies of material.

Despite a series of meetings with DOE and the threat of a lawsuit since early 1984, the US producer group was unable to obtain any tangible relief from DOE. DOE spent much of 1984 developing enrichment policies that would allow retention of its market share which was under challenge from foreign suppliers and the secondary market.

The Uranium Producers vs. DOE Lawsuit

In December 1984, three US producers — Western Nuclear, Inc.; Energy Fuels Nuclear, Inc.; and Uranium Resources, Inc. — filed a five-count lawsuit against DOE in the US Tenth Circuit Court in Denver, Colorado. Judge Jim Carrigan was assigned the case. The lawsuit was the culmination of efforts, begun in 1980, to protect domestic uranium production from low-cost imports, and to maintain the viability of the domestic industry.

Count I requested a reimposition of the US embargo on the enrichment of foreign uranium. It asserted that, under the Atomic Energy Act (161(v), 42 U.S.C. 2201(v), enacted in 1964), DOE is obliged to limit the enrichment of foreign-origin uranium for domestic end use so as to "assure the

©NUEXCO 1987

maintenance of a viable domestic uranium industry." The producers asked the court to take three actions under this count:

1. To declare the meaning of the term "viable" as employed in 161(v);

2. To order DOE to begin proceedings leading to the adoption of limits on enrichment of foreign-source uranium for end use;

3. To order DOE to impose interim limitations on such enrichment, pending the outcome of the proceedings.

In *Count II*, the suit sought a declaration that the USEC is null and void and an order prohibiting DOE from adopting a generic enrichment contract without compliance with the Administrative Procedures Act. (On December 27, shortly after the filing of the suit, the General Accounting Office reported several irregularities in the USEC which may have violated the law, including:

1. The issuance of the new contract did not comply with the Administrative Procedures Act.

2. The price ceiling in the USEC was not authorized by the enrichment criteria.

3. Certain accounting procedures used to write down plant assets were misapplied.)

Count III sought to require DOE to allow customers to vary their tails assays at no charge, because the surcharge for the variable tails assay option (VTAO) under the USEC tends to reduce uranium consumption.

Count IV sought to prohibit the use of the federal government stockpile, either through sales of pre-production inventories or through over-feeding the enrichment cascades to save power costs.

Count V sought judicial validation and enforcement of the principle that the US industry shall be capable of supplying 100 percent of US requirements at any time, and under any hypothetical supply disruption.

In June 1985, a trade association called the Uranium Producers of America (UPA) was formed. The new association's main goals were the enactment of effective mill tailings legislation and the recognition by the government of an obligation to ensure that a major share of US uranium requirements will be supplied by domestic production. The UPA later filed a supporting brief on behalf of the plaintiffs in the lawsuit against DOE.

Carrigan's First Ruling — Invalidation of the USEC

In September 1985, two events took place that greatly affected the US, and the worldwide, uranium industry. In the US District Court, Judge Carrigan ruled that DOE's USEC "amounts to a change in criteria under which enrichment services are to be performed." Because the contract was not submitted to Congress for review as required by law, Carrigan declared the USEC null and void.

Judge Carrigan's ruling, first announced September 16 and amended September 19, addressed Count II of the five-count uranium producers' civil suit. Under the Atomic Energy Act, DOE is required to establish written criteria describing terms and conditions for enrichment services. Furthermore, the adoption of any new criteria requires submission of the contract to Congress for review. In his order, Judge Carrigan stated that the critical issue regarding the USEC was that it "...[amounted] to new criteria governing enrichment." He cited three examples:

1. Existing criteria governing enrichment required that the primary DOE enrichment contract must be of a Fixed Commitment type, which the USEC clearly is not.

2. The USEC sets a ceiling price for enrichment services, which conceivably could prevent the government from recovering its costs. In 1973, for the same reasons, a similar provision which guaranteed a ceiling price was deleted from original criteria established in 1966.

3. Provisions in the USEC that base termination penalties on the period of notice that the customer gives DOE, rather than on recovery costs derived from DOE estimates of customer terminations, should be considered new criteria.

Thus, Judge Carrigan declared the contract null and void, and entered a summary judgment in favor of the producer group and against DOE with respect to Count II of the suit. DOE then filed a notice of its intent to appeal the ruling, a measure which extended to 60 days the period allowed for filing an appeal.

Non-Viability of the US Uranium Industry

On September 26, 1985, one week after Carrigan's ruling on Count II of the lawsuit, Energy Secretary Herrington announced that the US uranium industry was not viable. Declaring that "I have taken steps to help the miners and millers in this important industry that is currently under a great deal of strain", he:

1. Authorized DOE to offer a free VTAO each year to all customers that commit to buy 100 percent of their requirements from DOE over a rolling five-year period. It would save about $9/SWU for customers selecting 0.30 weight-percent tails. This item was being sought under the still-pending Count III of the producers' suit against DOE.

2. Postponed for one year a DOE plan to feed some of its own uranium stockpile into enrichment plants. This item was also sought in the producers' suit (Count IV).

3. He asked the US Trade Representative to examine the

facts and implications of uranium imports and corresponding foreign trade and policy issues with a view to determining the appropriate courses of action under US trade laws.

One of the reasons given for Herrington's declaration of non-viability was the US mining industry's reported loss of more than $200 million for 1984. That amount was a decline of $240 million from 1983, when the industry reported a net profit of almost $40 million, which enabled then-Energy Secretary Hodel to declare the industry viable. Those figures did not take into account the producers that had already been forced out of the business. That DOE was able to wait so long to recognize what had been evident for at least three years indicated that the entire issue of the industry's viability was determined much more by political factors than by economic ones.

Following the non-viability determination, the Justice Department, on behalf of DOE, and the three US producer plaintiffs, filed a new round of cross-motions for summary judgment in the Denver lawsuit. In addition, the UPA filed an *amicus curiae* brief on behalf of the plaintiffs. The plaintiffs' principal thrust was aimed at Count I of the suit, and argued that since the industry had been found non-viable, DOE must *immediately* cease all enrichment of non-US uranium destined for use in US reactors, pending development of new criteria governing the use of non-US-origin material.

Proposed New Criteria Governing Enrichment

On January 29, 1986, DOE formally proposed new criteria to govern its uranium enrichment contracts. The new criteria, submitted in a proposed amendment to the US Code of Federal Regulations, constituted the first substantial response to Carrigan's ruling that the USEC did not conform to the existing criteria governing DOE contracts. (Report 206 [October 1985] describes the Court ruling and the lawsuit against DOE.)

Apparently concluding that the most favorable response consisted of changing the federal regulations governing enrichment, DOE drafted extensive revisions to the existing criteria, and submitted the proposed criteria for a 45-day Congressional review once the final wording was established. Among the proposed changes in the criteria were the following significant points.

1. *Enrichment of Foreign-Origin Uranium.* (§762.3) "Domestic customers must certify the country of origin of feed material delivered to DOE." No restrictions were specified against any particular origin, and non-US customers were not required to certify feed origin. The rationale was that this requirement would facilitate the monitoring of non-US uranium use.

2. *Prices.* (§762.4) "DOE shall negotiate prices in individual enrichment contracts in accordance with an overall approach intended to maintain the long-term competitive position of DOE while obtaining the recovery of the government's costs over a reasonable period of time." Because neither the phrase "long-term competitive position" nor " a reasonable period of time" were defined, this section could be used by DOE to justify a wide-ranging, subjective price structure which varies from one customer to another and *is* not subject to Congressional review. There was no reference to floor or ceiling prices.

3. *Costs.* (§762.5) "DOE will establish charges for enrichment services on a basis that recovers appropriate government costs over a reasonable period of time. Such costs will be determined on a basis that includes the costs incurred in providing enrichment services to civilian customers..." DOE apparently sought to assure its customers that it would not spend more than it earns. Nevertheless, the unspecified time constraint and the term "*appropriate* government costs" allowed DOE ample flexibility to act in an unaccountable manner in any particular fiscal year.

4. *Nondiscrimination.* (§762.7) "The same prices, as well as other terms and conditions, shall be available to all similarly situated customers on a nondiscriminatory basis, reflecting the cost of the enrichment services supplied to those customers." The nondiscriminatory claim was effectively nullified by the ambiguity of the phrase "similarly situated."

Carrigan Rules on Remaining Counts

On June 20, 1986, Judge Carrigan issued his ruling on the remaining counts in the lawsuit filed in December 1984. The full text of Carrigan's order, covering Counts I, III, IV and V, is reprinted below.

Count I, which asserted that DOE violated the Atomic Energy Act of 1954 [42 U.S.C. Sec. 2201(v) as amended], remained the most significant issue in the litigation. Part of the Act states that DOE, "...to the extent necessary to assure a viable domestic uranium industry, shall not offer such (enrichment) services for source or special nuclear materials of foreign origin intended for use in a utilization facility within or under jurisdiction of the United States." In September 1985, the Secretary of Energy had declared the US industry non-viable. On the basis of that declaration and other arguments, Carrigan found that the producers were indeed entitled to relief under section 2201(v) of the Atomic Energy Act.

The producers had earlier asked the Court to order DOE to commence a rulemaking leading to the adoption of limits on the enrichment of foreign-source uranium for domestic end use, and to impose interim limitations on such enrichment pending the outcome of those proceedings. Carrigan ruled that DOE had violated the Act, denied DOE's requests to stay the proceedings, and granted the producers' motion for summary judgment. Carrigan then asked that counsel for plaintiffs and defendents jointly prepare for his signature an order consistent with his ruling. The counsel for DOE declined to participate. The producers' proposed order contained the provision that 75 percent of the uranium enriched by DOE from June 6, 1986, to December 31, 1986, for use in US reactors must be of US origin; and that as of January 1, 1987, and continuing until the viability of the domestic uranium industry was assured, DOE shall not enrich any non-US-origin uranium for use in US reactors.

DOE filed an opposition to the proposed order, listing as grounds the following:

1. "An injunction placing any restrictions on enrichment of foreign (uranium) by DOE will create hardships for DOE, the domestic utilities and their customers, and raises serious international policy issues..."

2. (The proposed order) "is inconsistent with 42 U.S.C. Sec. 2201(v) and exceeds the request for injunctive relief requested by (the producers)... Any such injunction clearly usurps both the role of the executive branch to establish criteria and the role of the legislative branch to review such criteria."

DOE concluded by requesting that the proposed order be modified accordingly. However, the order signed by Carrigan closely resembled the producers' draft. It called for immediate *injunctive* relief, ordering the same provisions for limitations on enrichment of foreign uranium for use in US reactors as were contained in the producers' proposal. (Injunctive relief requires some action on the part of DOE, as opposed to *declaratory* relief, which only would have expressed the opinion of the Court without ordering anything to be done.) Carrigan added that, if DOE believed that *less restrictive* criteria would be sufficient to maintain a viable domestic

---

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLORADO

Civil Action No. 84-C-2315

WESTERN NUCLEAR, INC., et al.,

Plaintiffs,

v.

F. CLARK HUFFMAN, et al.,

Defendants.

ORDER

CARRIGAN, J.

Oral argument was heard on June 5, 1986, on all pending motions in this case. The motions are directed to counts I, III, IV and V of the plaintiffs' complaint. Having heard the arguments of counsel with respect to the pending motions, having read the extensive briefs, and being fully advised, I hereby enter the following orders:

1. Plaintiffs' Motion for Summary Judgment with respect to Count I is granted and the defendants' Cross-motion for Summary Judgment with respect to Count I is denied. Defendants' request for a stay with respect to Count I is denied.

In light of the record, including affidavits submitted by the plaintiffs and *amici*, and including the information contained as part of the Secretary of Energy's determination in September 1985 that the domestic uranium industry was not viable, and in light of the Department of Energy's continuing refusal to recognize its obligations under 42 U.S.C. § 2201(v), I find that there is an immediate necessity for injunctive relief and therefore order as follows:

Given the Department of Energy's need to plan its implementation of the mandate of § 161(v) of the Atomic Energy Act, 42 U.S.C. § 2201(v), and pending the completion of the rule-making ordered herein: (a) the Department shall restrict its enrichment of source or special nuclear materials of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States to twenty-five percent of such materials enriched over the time period June 6, 1986, to December 31, 1986; (b) as of January 1, 1987, and continuing until the viability of the domestic uranium industry is assured, the Department shall not offer or provide any enrichment services for source or special nuclear materials of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States.

The Department shall commence administrative rule-making proceedings to establish criteria for providing enrichment services that shall comply with the mandate of 42 U.S.C. § 2201(v) to assure the maintenance of a viable domestic uranium industry. These criteria shall include the extent to which enrichment services may be made available for source or special nuclear material of foreign origin intended for use in a utilization facility within or under the jurisdiction of the United States. If the Department believes that criteria less restrictive than those imposed by this order would assure the maintenance of a viable domestic uranium industry, then the Department shall clearly articulate its reasons for such a position.

The court retains jurisdiction of this matter to assure compliance with this order.

2. With respect to the issues raised by Count III of the complaint, and the motions pending concerning Count III of the complaint, the defendants' Motion for Stay is granted for ninety days.

3. With respect to Count IV of the complaint, the defendants' Motion to Dismiss is denied and the defendants' Motion for Stay is denied. The defendants' Motion for Summary Judgment with respect to Count IV is granted.

4. Upon motion of the plaintiffs, there being no objection from the defendants, the plaintiffs are granted leave to withdraw Count V of their complaint without prejudice.

Dated at Denver, Colorado, June 10, 1986.

BY THE COURT:
JIM R. CARRIGAN, JUDGE
UNITED STATES DISTRICT COURT

uranium industry, DOE must "clearly articulate its reasons for such a position." Carrigan also retained jurisdiction over the matter to assure compliance with the order.

Several days later, DOE filed three documents in the District Court.

1. A *Notice of Appeal* advised that DOE was appealing to the Tenth Circuit Court of Appeals the order granting the producers summary judgment on Count I and entering an injunction on that Count.

2. A *Motion for Stay Pending Appeal* requested an order staying the injunction entered by Carrigan, pending resolution of the appeal on Count I.

3. A *Memorandum in Support of Motion for Stay Pending Appeal* argued the rationale behind DOE's motion for stay pending appeal.

While the issues in Count I had caused the greatest amount of speculation and concern, Judge Carrigan also ruled on the remaining counts in the lawsuit. (He had ruled on Count II in September 1985.) *Count III* sought to require DOE to allow customers to vary their tails assays at no charge, because the surcharge for the variable tails assay option (VTAO) under the USEC tends to reduce uranium consumption. Carrigan granted DOE's motion for a stay of proceedings for 90 days.

Count IV sought to prohibit the use of the federal government stockpile, either through sales of pre-production inventories or through over-feeding the enrichment cascades (to save power costs). Apparently persuaded that DOE had not and would not be using its stockpile in such a manner, Carrigan denied DOE's motions for dismissal and stay, but granted summary judgment *in favor of DOE* on this issue.

At the Court's suggestion, producers' counsel moved to *withdraw Count V*, and leave was granted to withdraw it without prejudice. Among other issues, Count V had sought judicial validation and enforcement of the principle that the US uranium industry shall be maintained in a condition such that it shall be capable of supplying 100 percent of US requirements at any time.

DOE Appeals the Decision

Observers expected Judge Carrigan to either grant or deny the motion for stay within a few weeks, but as of early July 1986, he had not responded. DOE then took the stay request to the Tenth Circuit Court of Appeals (which has jurisdiction over matters under appeal from the District Court). DOE's application to stay the order was heard by three Circuit Court Judges, who ruled on July 21, 1986, that the order be stayed until further order of the Circuit Court.

The Circuit Court also ordered that the issues involving Count I should be argued and submitted together with the issues of Count II of the five-count lawsuit, in an expedited hearing on September 11, 1986. (Count II pertained to the legality of the USEC, which Judge Carrigan ruled to be null and void in September 1985.) That issue had been under appeal in the Tenth Circuit Court since then.

DOE's *Memorandum in Support of Motion for Stay Pending Appeal* was reprinted in its entirety in Report 215 (July 1986). It argued the rationale behind DOE's motion for stay pending appeal. Among other reasons, DOE stated that:

1. DOE already had in its possession a high percentage of foreign feedstocks designated for use in US reactors. DOE claimed the order would prevent it from enriching all of the delivered feedstock needed for US reactors. Therefore, domestic utilities and DOE would suffer "irreparable injury without a stay," which "could result in shutdowns of domestic reactors."

2. The injunction "impacts adversely on foreign trade, foreign policy, and the nuclear non-proliferation policy of the United States," and is not in the public interest.

3. Finally, DOE maintained that the injunction oversteps the limits of statutory interpretation, equating Carrigan's injunction with judicial rulemaking in that it effectively changes the enrichment criteria without Congressional review as required by the Atomic Energy Act.

The stay pending appeal of the District Court injunction effectively delayed the onset of some potential problems for DOE At least two US utilities had notified DOE that they intended to deliver non-US origin feed for upcoming enrichment campaigns. If DOE had responded that it could not enrich that material under the terms of the injunction, those utilities might have turned to the secondary market for enrichment or to one of the primary enrichers overseas for that delivery. It is possible that some USEC holders would have followed with similar strategies in the next few months if the stay had not been granted, but it is likely that only those with substantial inventories of non-US feed would have responded in that manner.

Issuance of the Proposed Enrichment Criteria — July 1986

On July 24, DOE's final wording of the criteria had been established and was submitted to Congress. It appeared in the *Federal Register* on July 29, 1986. Prior to 1977, the Joint Committee on Atomic Energy (which consisted of members of both the House of Representatives and the Senate) provided oversight of AEC activities, including the review of uranium enrichment criteria. That committee was abolished in 1977, and although its functions have been assigned to other House and Senate subcommittees, no particular committees were specified.

©NUEXCO 1987

In general, the proposed criteria submitted to Congress in July 1986 were not substantially different than the language issued for review and comment in January. DOE stated that it had "considered all the comments carefully in its deliberations concerning the revised criteria and has modified the proposed criteria where appropriate." These modifications included the following.

1. *General* (§762.1) — Two additions to this section required that enrichment contracts must specify the customer's commitment to DOE to take services and the charge for cancellation of that commitment, and that contracts must be long term in nature, unless a short-term contract would "promote the objectives of the [Atomic Energy Act]."

2. *Enrichment of Uranium of Foreign Origin* (§762.3) — DOE removed the sentence requiring US customers to certify the country of origin of the feed material, replacing it with, "DOE may not restrict the enrichment of uranium of foreign origin for domestic use except to the extent it determines such a restriction is necessary to assure the maintenance of a viable domestic uranium industry." This new wording carefully tied the issue of industry viability with foreign uranium enrichment restrictions, giving DOE the perogative to decide whether restrictions would actually help the US industry. If DOE determined that restricting the enrichment of foreign uranium would not sufficiently revive the US production industry, it would not be compelled to act. Indeed, DOE had already argued (with support from the US Trade Representative, among others) that enrichment restrictions would not necessarily assure the viability of the US industry. Predictably, this revision was consistent with the legal argument made by DOE with respect to Count I in the producers' lawsuit against DOE (see Report 215 [July 1986], page 3).

In an extensive argument in the *Supplementary Information* to the proposed criteria submitted to Congress, DOE noted the existence of the US District Court injunction preventing it from enriching foreign-origin uranium for US use. (The injunction was at that time stayed pending appeal.) However, DOE stated that it "believes that the [District Court] judgment is erroneous." DOE added, "In adopting section 762.3, DOE is mindful of the ongoing nature of the...litigation. Section 762.3 is being adopted at this time, notwithstanding the...litigation, in order to formally record DOE's interpretation of Section 161(v) (of the Atomic Energy Act), (and) to state DOE's determination that restrictions on enrichment of foreign-origin uranium continue to be inappropriate..."

The Criteria's Relationship to the District Court Rulings

A US District Court ruling interpreting a federal statute will take precedence over an administrative rulemaking. Thus, if upheld in the Tenth Circuit Court of Appeals, Judge Carrigan's order requiring limitations on the enrichment of foreign-origin uranium for use in US reactors would take effect (absent further stays or appeals) regardless of any DOE rulemaking on that issue, or the presence of criteria which specifically prohibit limitations. Moreover, as part of his ruling, Carrigan had ordered DOE to commence a rulemaking procedure to establish criteria consistent with his order. In essence, DOE ignored that order and proceeded with a rulemaking that was consistent with its interpretation of the relevant portions of the Atomic Energy Act that deal with assuring the viability of the domestic uranium industry.

The validity of the last section (§762.15) of the proposed criteria also depended on the outcome of the producer/DOE litigation on appeal before the Tenth Circuit. Judge Carrigan ruled (as to Count II of the lawsuit) that certain terms contained in the USEC amounted to a change in the criteria governing enrichment, and, because there had been no Congressional review, the contract was null and void. "Prior Contracts" (§762.15) states that "All contracts under which DOE was providing enrichment services prior to the adoption of these criteria are valid. These prior contracts may be amended to conform to these criteria without penalty, if both parties agree." DOE received comments to the effect that this section was an improper attempt to retroactively validate the USEC following Carrigan's null and void ruling. However, DOE maintained that "a change in criteria should not invalidate existing contracts," and that the contracts were negotiated "in good faith between DOE and its customers." Again, DOE had to prevail in the appeal process in order to successfully implement this section of the criteria.

Congressional Action on the Enrichment Criteria

In October 1986, Congress unexpectedly failed to disapprove the new enrichment criteria that DOE had proposed on July 24. Although separate joint resolutions were passed in the Senate and House of Representatives to disapprove the criteria, Congress was unable to attach the resolutions to any pending legislation. One resolution had been attached as an amendment to a virtually veto-proof debt reduction bill, but the bill was stripped of all amendments immediately prior to its passage.

Congress did, however, succeed in effectively nullifying those sections of the new criteria that had caused the most controversy by passing a joint resolution with the following introduction:

"None of the funds provided in this joint resolution or in any other law may be used to implement the following provisions of the uranium enrichment criteria submitted to Congress on July 24, 1986."

©NUEXCO 1987

In effect, the resolution provides for funding of the new criteria, except for five important sections. Those sections denied government funding (effectively making them difficult to implement) are the following.

1. "Section 762.3, which specifies the permitted enrichment of source material of foreign origin for use in domestic utilization facilities."

2. "The third sentence of section 762.11 (pertaining to quantities and form of feed and product material), to the extent that it provides limitations on free choice of transaction tails assays from 0.2 to 0.3 w/o U_{235} or imposition of an additional charge for selections in that range." In other words, DOE had to provide a free Variable Tails Assay Option (VTAO).

3. "Section 762.15 (pertaining to prior enrichment contracts), to the extent it might be construed to validate contract provisions permitting unrestricted delivery and enrichment of foreign-origin feed material after a final court decision requiring restriction(s) ... or permitting imposition of additional charges" for the VTAO. In other words, DOE could not implement this section in order to circumvent a court decision requiring foreign-origin uranium restrictions or a VTAO surcharge.

4. "Any portion of the criteria or provision in any contract which permits or results in a reduction of the amount of feed material otherwise required to be delivered to DOE by commercial customers as a result of the use of uranium from government stockpiles ... ", i.e., the practice of over-feeding from the DOE stockpile.

5. "Section 762.6 (Recovery of Prior Unrecouped Government Costs), insofar as it may convey a determination of the level of unrecouped costs that must be returned to the Treasury by the enrichment program, which determination shall be made by the Congress in future legislation." Thus, the issue of the size of DOE's enrichment debt would be postponed until Congress reviewed it again.

In essence, by withholding funding for those sections, Congress stripped the criteria of the most controversial provisions. Congress appears intent on studying the cost recovery issue further, rather than allowing DOE to establish prices and costs based on its determination of the enrichment debt. In effect, the USEC was partially approved by the resolution, but those provisions of the contract relating to foreign-origin enrichment, the free VTAO, and over-feeding from the DOE stockpile were not approved. As far as the question of enrichment of foreign-origin uranium for US use, Congress specifically stated that the issue was to be decided entirely by the outcome of the DOE/US producers litigation.

"... foreign-origin uranium may be enriched for domestic use only until a final judgment or dismissal in the pending litigation that determines whether section 161(v) of the Atomic Energy Act requires restriction of enrichment of foreign-origin source material, in which case the criteria shall be amended to impose such restrictions, or such unrestricted enrichment may continue, whichever is consistent with the decision of this question in the pending litigation..."

Thus, Congress would not allow DOE to use the new criteria to circumvent the decision that would be made by the Tenth Circuit Court regarding restrictions of foreign-origin uranium. Moreover, Congress made it clear that its joint resolution should have no impact on the court's upcoming decision:

"No provision of this joint resolution or the July 24, 1986 criteria shall affect the merits of the legal position of any of the parties...in the pending litigation in the United States Court of Appeals for the Tenth Circuit..."

Conclusion

During the latter half of 1986 and throughout the first half of 1987, until the July 20 decision by the Appeals Court, the lawsuit's effect on the uranium market was primarily one of uncertainty. Nearly all participants in the nuclear fuel market, but especially those in the USA, waited anxiously for a resolution of the lawsuit. Many US utilities and producers have used the year since the appeal was granted to adjust their inventories, increasing the amount of US-origin material held, in anticipation of a situation in which only US-origin might be usable as enrichment feed at DOE.

However, even though a decision has been reached by the Appeals Court, several avenues still are available for DOE to contest the ruling. Essentially, the case has come to pivot on an eventual final ruling on Count I of the suit — whether DOE will be required to limit enrichment of non-US-origin uranium. While that legal matter awaits resolution, it is probable that Congress will take the necessary steps to decide the issue of whether the US uranium production industry should be protected against competition from lower-cost uranium imports.

© NUEXCO 1987

July 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.75**/lb. U_3O_8	2,830	2,545
UF_6 VALUE	**$47.50**/kgU		
CONVERSION VALUE	**$1.90**/lb. U as UF_6	0	440
SWU VALUE 0.3 tails assay; delivery within one year	**$75**/SWU		
LOAN RATE	**3%**/annum	1,000	—

	$/lb. U_3O_8	**Millions of Pounds**	**Number of Transactions**	**Number of Months**
TRANSACTION VALUE	**17.30**	3.8	19	3

[1] Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**
Australia (dollar)	23.99	23.43	27.96	62.36	60.92	72.69
Belgium (comm. franc)	642.75	640.15	742.68	1,671	1,664	1,931
Canada (dollar)	22.32	22.53	23.51	58.01	58.58	61.13
EEC (ecu)	14.99	14.91	17.00	38.97	38.77	44.20
Finland (markka)	75.38	75.21	85.34	195.98	195.53	221.87
France (franc)	103.27	103.11	116.44	268.47	268.07	302.71
FRG (mark)	31.06	30.90	35.89	80.75	80.34	93.30
Italy (lira)	22,477	22,411	25,648	58,436	58,263	64,080
Japan (yen)	2,503	2,478	2,640	6,506	6,443	6,864
Netherlands (guilder)	34.98	34.82	40.46	90.93	90.53	105.18
South Africa (rand)	34.72	34.53	42.43	90.25	89.76	110.30
Spain (peseta)	2,117	2,415	2,310	5,505	6,278	6,007
Sweden (krona)	108.27	107.92	118.96	281.49	280.56	309.28
Switzerland (franc)	25.74	25.68	28.80	66.91	66.76	74.87
UK (pound)	10.50	10.56	11.39	27.30	27.45	29.62
US (dollar)	16.75	16.90	17.00	43.55	43.94	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**
Australia (dollar)	24.77	23.71	28.78	64.41	61.64	74.83
Belgium (comm. franc)	663.85	647.73	764.53	1,726	1,684	1,988
Canada (dollar)	23.05	22.80	24.20	59.92	59.27	62.93
EEC (ecu)	15.48	15.09	17.50	40.25	39.23	45.50
Finland (markka)	77.86	76.10	87.85	202.41	197.85	228.39
France (franc)	106.66	104.33	119.86	277.29	271.24	311.62
FRG (mark)	32.08	31.27	36.94	83.40	81.29	96.04
Italy (lira)	23,215	22,676	25,373	60,354	58,953	65,965
Japan (yen)	2,585	2,508	2,718	6,720	6,519	7,066
Netherlands (guilder)	36.12	35.24	41.65	93.92	91.61	108.27
South Africa (rand)	35.85	34.93	43.67	93.21	90.82	113.54
Spain (peseta)	2,187	2,444	2,378	5,685	6,353	6,183
Sweden (krona)	111.83	109.20	122.46	290.73	283.88	318.38
Switzerland (franc)	26.58	25.98	29.65	69.11	67.55	77.07
UK (pound)	10.85	10.68	11.73	28.20	27.78	30.49
US (dollar)	17.30	17.10	17.50	44.98	44.46	44.50

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on July 31, 1987.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**	**This Month (July 31, 1987)**	**Last Month (June 30, 1987)**	**12 Months Ago (July 31, 1986)**
Australia (dollar)	2.72	2.50	2.96	6.00	5.50	6.53
Belgium (comm. franc)	72.91	68.18	78.64	160.74	150.31	173.36
Canada (dollar)	2.53	2.40	2.49	5.58	5.29	5.49
EEC (ecu)	1.70	1.59	1.80	3.75	3.50	3.97
Finland (markka)	8.55	8.01	9.04	18.85	17.66	19.92
France (franc)	11.71	10.98	12.33	25.82	24.21	27.18
FRG (mark)	3.52	3.29	3.80	7.77	7.26	8.38
Italy (lira)	2,550	2,387	2,610	5,621	5,262	5,754
Japan (yen)	283.88	263.97	279.55	625.84	581.95	616.29
Netherlands (guilder)	3.97	3.71	4.28	8.75	8.18	9.44
South Africa (rand)	3.94	3.68	4.49	8.68	8.11	9.90
Spain (peseta)	240.17	257.22	244.63	529.49	567.06	539.32
Sweden (krona)	12.28	11.49	12.60	27.08	25.34	27.77
Switzerland (franc)	2.92	2.74	3.05	6.44	6.03	6.72
UK (pound)	1.19	1.12	1.21	2.63	2.48	2.66
US (dollar)	1.90	1.80	1.80	4.19	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU VALUE delivery within one year (July 31, 1987)**	**UF_6 Value per kg.U in UF_6 This Month (July 31, 1987)**	**UF_6 Value per kg.U in UF_6 Last Month (June 30, 1987)**
Australia (dollar)	107.40	68.02	66.20
Belgium (comm. franc)	2,878	1,823	1,809
Canada (dollar)	99.92	63.28	63.66
EEC (ecu)	67.12	42.50	42.13
Finland (markka)	337.53	213.77	212.50
France (franc)	462.39	292.84	291.33
FRG (mark)	139.07	88.07	87.31
Italy (lira)	100,644	63,741	63,321
Japan (yen)	11,206	7,097	7,002
Netherlands (guilder)	156.61	99.18	98.39
South Africa (rand)	155.44	98.44	97.54
Spain (peseta)	9,480	6,004	6,823
Sweden (krona)	484.81	307.04	304.91
Switzerland (franc)	115.24	72.98	72.55
UK (pound)	47.02	29.78	29.83
US (dollar)	75.00	47.50	47.75

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on July 31, 1987.

© NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4108	1987	101-300	88-92	Producer	Utility	US-origin
4120	1987	101-300	R[6]	Intermediary	Utility	
4122	1987	50-100	98-102	Intermediary	Utility	UF_6
4125	1987-88	301-600	98-102	Intermediary	Utility	
4126	1987	101-300	98-102	Intermediary	Utility	US-origin UF_6
4127	1988	50-100	98-102	Intermediary	Utility	US-origin
4128	1988	101-300	98-102	Intermediary	Utility	US-origin
4129	1987	101-300	98-102	Producer	Utility	UF_6

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] Where US-origin material is involved, the range includes the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value).

[3] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[4] Prices are usually normalized to 0.3% tails assay.

[5] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[6] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

Conversion Services Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
4101	1987	101-300	88-92	Intermediary	Utility	
4119	1987	330	R[5]	Utility	R[5]	
4124	1988	101-300	128-132	Intermediary	Utility	

Loan Transactions

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Loan Rate	Lender	Borrower	Remarks
4112	1987	301-600	R[5]	Utility	Producer	US-origin UF_6
4118	1987	101-300	R[5]	Utility	Utility	UF_6

Enrichment Services Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4130	1988	101-300	98-102	Utility	Utility	DOE	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.3% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.

[5] The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(July 31, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2335	270	—	
2764B*	150	—	UF_6
2893A	720	—	UF_6
2989	40	—	
2996*	500	500 per year	1988-90
3023	400	500	UF_6
3121*	500	—	
3244	250	300 per year	1988-93
2263	—	400 per year	1989 on
2781	—	400 per year	1988-95
3123		2,000	1988
3138A*		325	1988
3171	—	200 per year	1988-92
TOTAL:	2,830		
INACTIVE			
2297	100	100 per year	1988-89
2933	300	300 per year	1988-90
2967	1,000	—	
3168	50	100 per year	1988-92
3174*	1,550	—	UF_6
3280*	120	—	UF_6
2981	—	600 per year	1988-91
3128	—	100	1988 on
3230*		500	1988 on
TOTAL:	3,120		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2625, 3238.

©NUEXCO 1987

URANIUM DEMAND
(July 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2893C*	700		UF_6
3149*	300	300	1989
3152*	260	—	UF_6
3192A*	500	—	
3220*	250	—	
3285*	300	—	
2936*	—	1,200 per year	1990-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3137	—	4,800 per year	1993-97
3193	—	700 per year	1989, 91, 94, 96
TOTAL:	2,485		
INACTIVE			
2798	150	—	
TOTAL:	150		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2738, 2911, 2984, 3120, 3220, 3249, 3251, 3312.

© NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(July 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF$_6$) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale:			
INACTIVE			
2859	750	750	
3165	330	—	
TOTAL:	1,080		
Inquiries to Purchase:			
ACTIVE			
3151*	440	—	
TOTAL:	440		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: 3222.

©NUEXCO 1987

LOAN SUPPLY AND DEMAND
(July 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
3262*	600	—	
TOTAL:	1,600		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		
Inquiries to Borrow			
INACTIVE			
3192B*	50	—	
TOTAL:	50		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

SWU SUPPLY AND DEMAND
(July 31, 1987)

	Delivery Period[1] (Thousands of SWUs)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Available for Sale:			
ACTIVE			
2969	150	—	1988
3173	45	—	1987
TOTAL:	195		
INACTIVE			
2571	55	—	1987
3213	300	—	
3280*	25	—	
3291	50	—	1987
TOTAL:	430		
Inquiries to Purchase:			
ACTIVE			
2999	25		1988
3286*	150	—	1988
TOTAL:	175		
INACTIVE			
3159*	30	—	
TOTAL:	30		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: none.

©NUEXCO 1987

US URANIUM TRADE RESTRICTION ANALYSIS

This article summarizes part of Nuexco's supply-demand forecast for the remainder of this century. A more detailed analysis is presented in Nuexco's Uranium Market Study and Price Forecast.

Introduction

This analysis presents scenarios covering several possible restricted market conditions in the USA, that could affect the near to mid-term uranium market. This information is particularly timely in view of the US Court of Appeals' decision affirming Judge Carrigan's earlier decision in the US Producers vs DOE lawsuit. This decision prohibits DOE's enrichment of non-US-origin uranium for use in reactors in the USA.

Nuexco projects in this analysis that an administrative or legislative solution will have been reached by the end of 1988. Congress could pass a law overriding the Circuit Court's prohibition, by placing limits on imports of uranium into the USA, or DOE could conduct an administrative rulemaking to establish the conditions that will be used to "ensure viability" of the US uranium production sector. Any such rulemaking would be subject to the approval of Judge Carrigan, before it could take effect.

Under several hypothetical import restriction cases, output from US producers is expected to increase, the extent of the increase depending on the level of restriction and whether existing contracts and inventories are grandfathered. (Grandfathering means that inventories in place or contracts concluded prior to a given date will be allowed.) Overall, there is a wide variation in the effects on uranium supply and demand, depending on the degree and type of restriction. It is clear that increases in US production above the current level will require price increases.

Inventories

Through the near term (early 1990s), excess uranium inventories will gradually decrease (Figure 1). In 1985 and 1986, for the first time in a number of years, uranium consumption was greater than production, resulting in a decrease in inventories.

Total uranium inventories normally consist of three components:

1. In-process material, which is uranium in some stage of processing into fuel assemblies, after delivery to the buyer as ore concentrates or UF_6.
2. Reserve stocks, independent of in-process material, which are intentionally held as contingency or strategic inventory to assure availability of uranium.
3. Excess inventory on hand, over and above the in-process and reserve inventories.

The categories may be rather fluid in how they are considered by utilities. For example, many utilities may choose to classify excess material as increased reserve stocks and, therefore, plan for its use within the utility. Nuexco's estimates of inventory, for the purposes of this analysis, *exclude* in-process material since it is not normally available for immediate sale. Although Nuexco data show total world uranium inventories as of the beginning of 1986 to have been approximately 500 million pounds U_3O_8 (equivalent to over 4 years forward supply), only about half of that amount, 255 million pounds, is classified as excess. This excess was equivalent to about 2.2 years forward supply. The total inventory included approximately 140 million pounds U_3O_8 held by producers and 360 million pounds held by utilities. Utilities in the Far East held the greatest relative inventory levels, by a substantial margin, both on a per-MWe and forward-coverage basis. European and US utilities held similar relative amounts, with the European utilities showing slightly higher inventory levels overall.

Uncommitted Supply

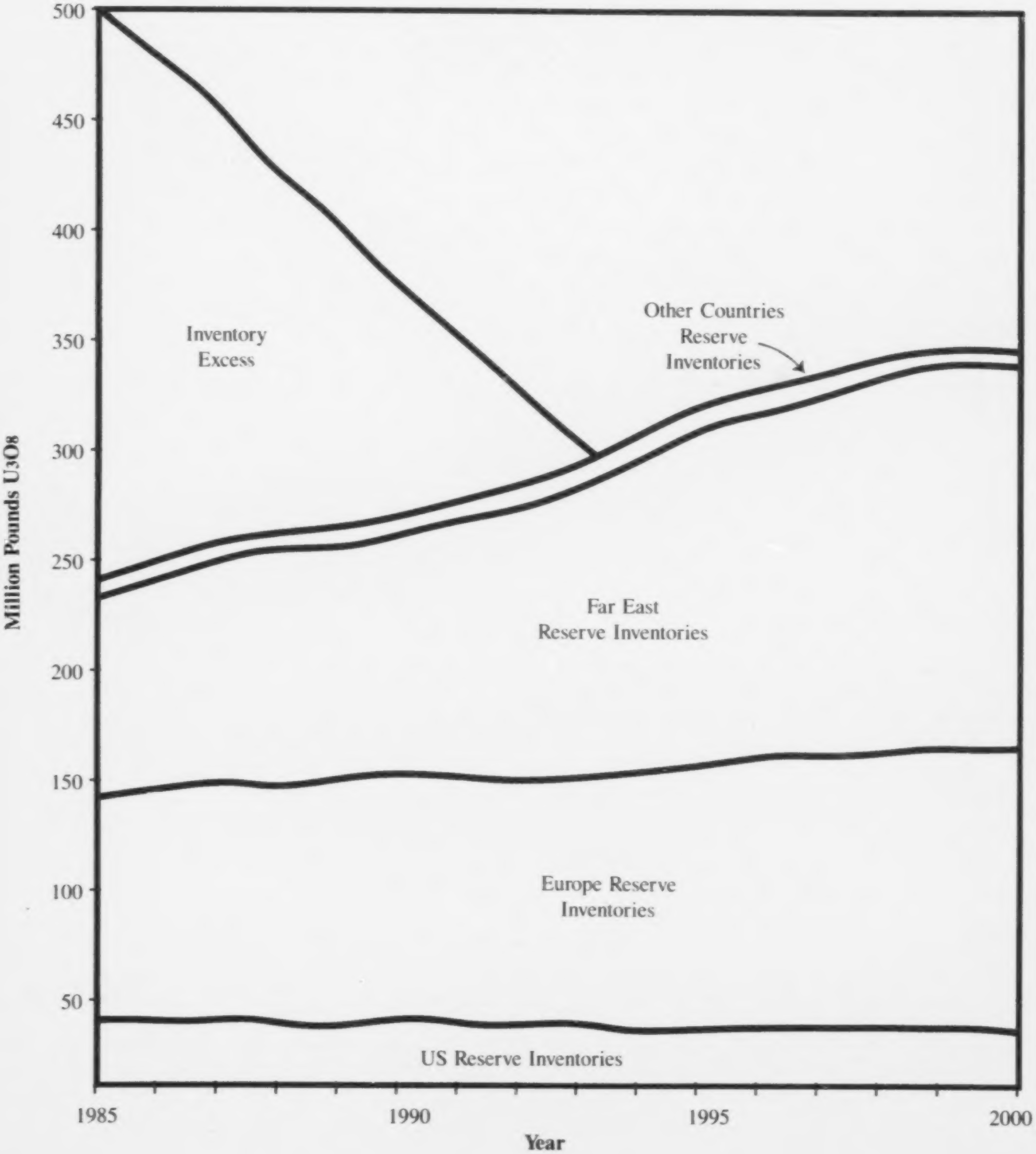
The amount of uranium a producer can deliver includes the producer's inventory, forecasted production, and deliveries of material to that producer that are purchased from others. A producer's uncommitted supply is the sum of those amounts less the producer's delivery commitments during that period. While some producers' commitments may exceed their total supply, most show some uncommitted supply. Some utilities and traders also have excess inventory that they intend to sell, which is included in uncommitted supply.

Any significant restrictions placed on imports into the USA will cause shifts not only in the production balance between US and non-US producers, but also in the markets available to non-US producers, affecting the calculation of uncommitted supply. This forecast includes analyses for free market, moderate, and severe US-market restrictions, respectively (Figure 2). A moderate restriction is assumed to be one in which a 50-percent import restriction is imposed, with full grandfathering of existing contracts allowed. A severe restriction would be one in which a 75-percent import limitation prevails. Increasing degrees of restriction will cause upward shifts in the uncommitted supply, because additional production in the USA will diminish non-US producers' access to the US market, and hence otherwise firm commitments in that market.

©NUEXCO 1987

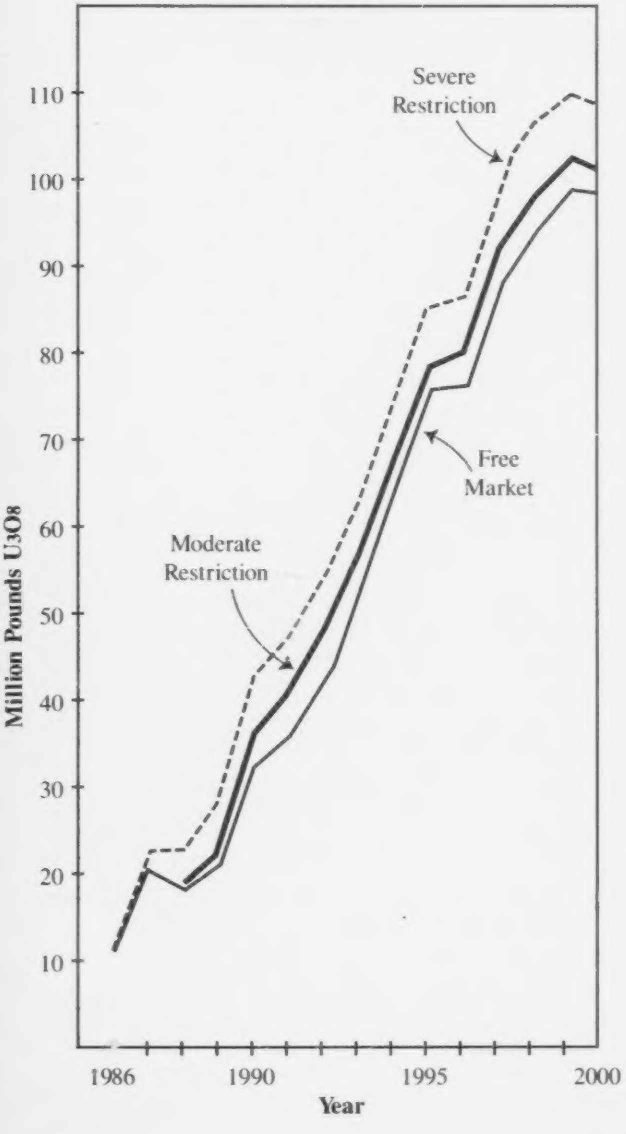
ANALYSIS & COMMENTARY

Figure 1
FORECAST OF WORLD URANIUM INVENTORIES
(excluding in-process material)



© NUEXCO 1987

Figure 2
EFFECT OF US MARKET RESTRICTION ON WORLD UNCOMMITTED URANIUM SUPPLY (1986-2000)



Material Balance

Assuming a free-market condition, inventories will decrease to the estimated required minimum by 1993. The required minimum is estimated using the different regions' reserve inventory forward requirements. The nominal year-end inventory takes into account inventory on hand at the beginning of each year, adds specified production (production expected to occur in all projected market cases), and subtracts projected annual consumption. Although no additional supplies will be needed to maintain an overall minimum inventory level in the near term, excess inventory will drop from approximately 200 million pounds U_3O_8 equivalent in 1987 to about 65 million pounds U_3O_8 equivalent by 1991. By 1993, the excess will have been used up and additional supplies will be needed to maintain minimum inventory levels.

Most of the 200 million pounds U_3O_8 equivalent in excess inventory at the end of 1987 will be used by the utilities holding it. A much smaller amount will be sold on the market during the forecast period, mainly from producer inventories. However, not all of the projected future demand increase will be supplied by increased uranium production — increasing use of reprocessing may supply a portion of the increase.

Unfilled Requirements

Unfilled requirements are the amounts of uranium that will be needed, but that have not yet been purchased. These requirements equal the future reactor consumption, less future deliveries under existing contracts, expected inventory drawdown (or plus expected inventory buildup, whichever is the case), and any equivalent fuel to be gained through spent fuel reprocessing. Most excess utility inventories are assumed to be held for future self-use by the utility.

There is a wide variation in inventory holdings: some utilities have large inventories and others do not, and in the near term, a number of utilities will have unfilled requirements. Over the forecast period, US utilities have the largest unfilled requirements. Comparing total consumption with unfilled requirements, the USA's unfilled portion is relatively much greater than that of the other geographic areas (Figure 3). Overall, world unfilled requirements are less than 20 percent of consumption through 1991, but increase thereafter.

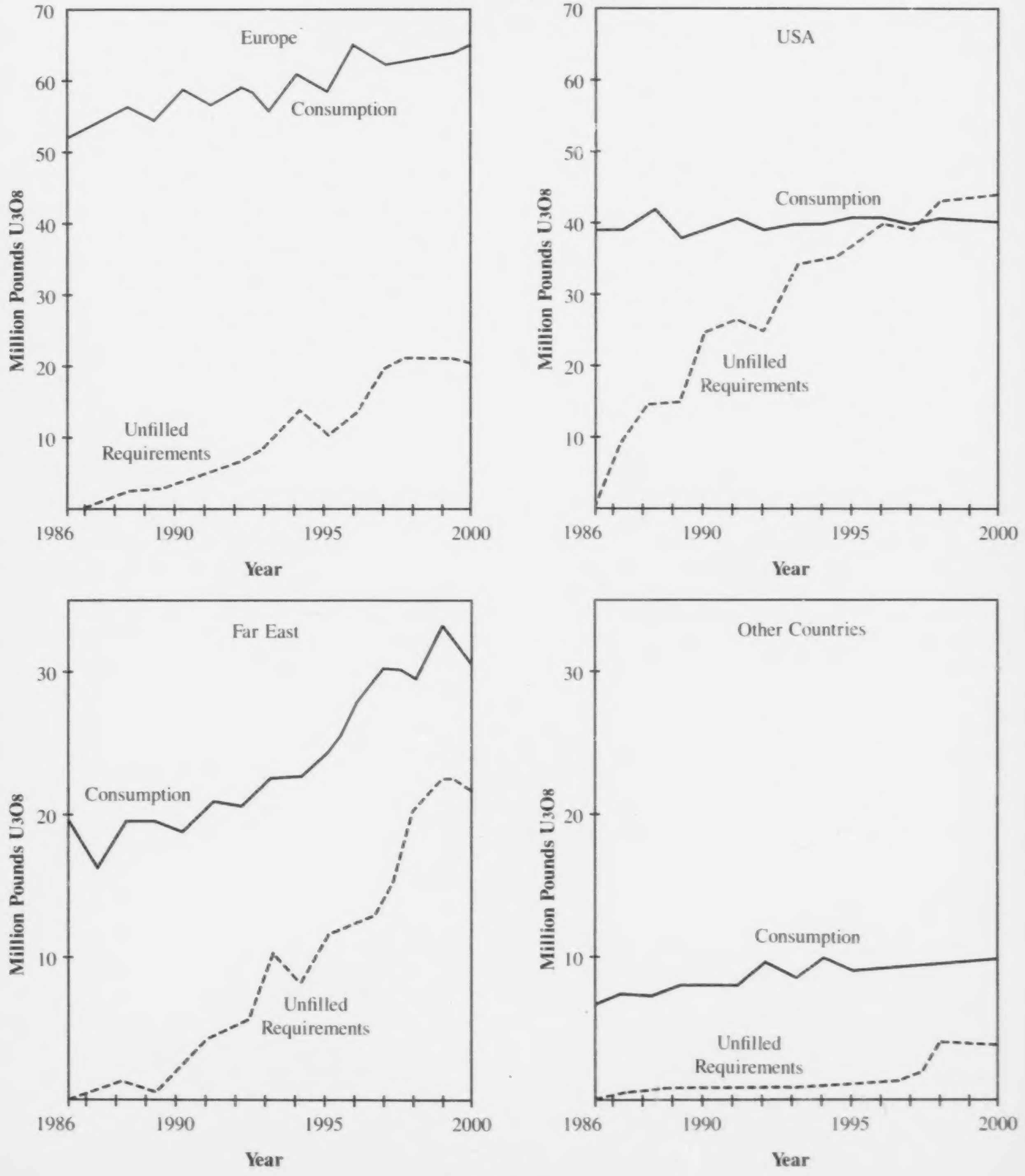
Supply and Demand in a Restricted Market

The Appellate Court ruling in July 1987 has supported Judge Carrigan's June 1986 ruling totally prohibiting the use of non-US-origin feed material for production of enriched uranium at DOE for subsequent use in a reactor in the USA. Our assumption is that a bill introduced into the US Congress in the current or next session (1988) will be enacted that reduces the total prohibition to a partial restriction. Alternatively, the litigants could reach a compromise level of import restriction. Nuexco postulates that such a reduced

©NUEXCO 1987

Figure 3

COMPARISONS OF TOTAL CONSUMPTION AND UNFILLED REQUIREMENTS (1986-2000)



© NUEXCO 1987

restriction would likely become effective at the beginning of 1989 meaning that some of 1987 and all of 1988 will fall under a total import restriction. Additionally, Nuexco's analysis indicates that a plausible level of restriction in the postulated Congressional bill or compromise would exceed 50 percent, because a less-than 50-percent restriction would not greatly stimulate the US production industry.

Nuexco's analysis shows that under a 50-percent restriction, with grandfathering of existing contracts allowed, little or no stimulation of US production would occur. In this scenario, about 240 million pounds of material would be allowed as imports through 2000.

If no grandfathering were allowed, approximately 76 million pounds of additional US production (above a free market scenario) would be required, and the total US-origin supply required through 2000 would amount to about 266 million pounds. (Under free market conditions, US production is projected to total 190 million pounds U_3O_8 for the period 1989-2000). Lacking the grandfathering provision, only about 160 million pounds of additional imported material would be allowed into the USA. These various US production levels are shown in Figure 4.

In the event of a 75-percent restriction, with grandfathering allowed, approximately 110 million pounds of additional US production, above the free market case, would be required through 2000. Allowable imports would be limited to about 120 million pounds. Under this same level of restriction, but with no grandfathering, about 200 million pounds additional US production above the free market case would be required, and required US-origin production would total about 385 million pounds. Only about 42 million pounds of imports would be allowed.

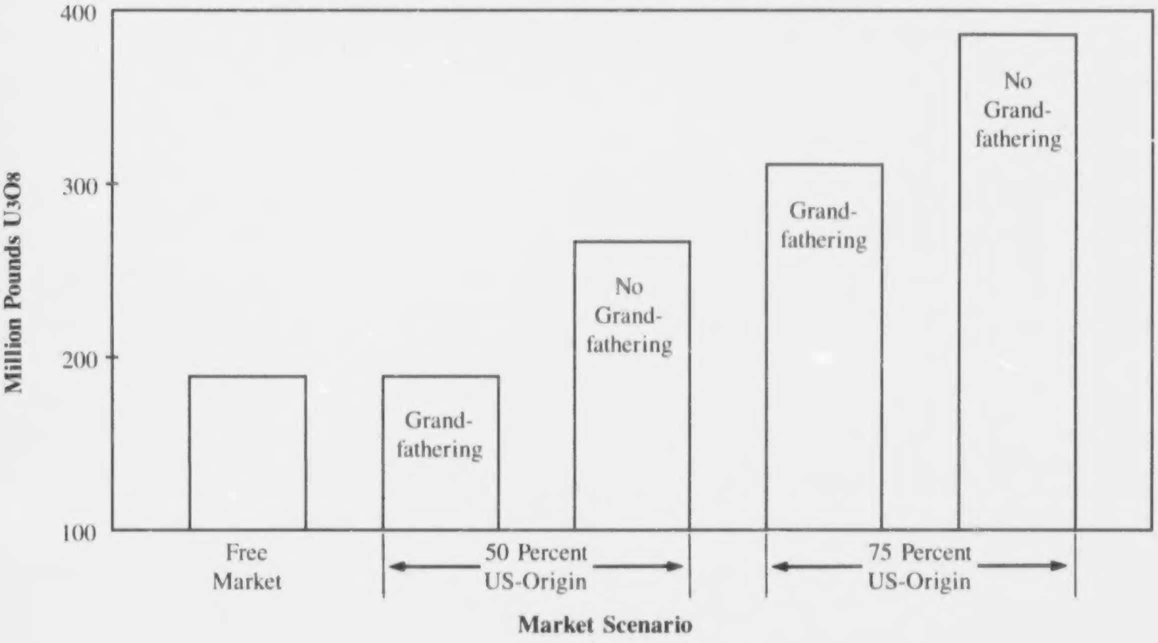
As can be seen from the annual production forecasts in Figure 5, the impact of the severe restriction, although major in terms of the US producing industry, is rather moderate on a worldwide basis.

Conclusion

This analysis of supply and demand assumes that, first, a total embargo on imports of non-US-origin uranium into the USA will be in effect from some time in mid-1987 through the end of 1988. It then assumes that legislative action or other compromise will reduce that level of import restriction from 100 percent to one of several hypothetical levels used for analysis, beginning in 1989.

Figure 4

**TOTAL US SUPPLY REQUIRED, 1989-2000
UNDER FREE MARKET AND RESTRICTED MARKET CONDITIONS**

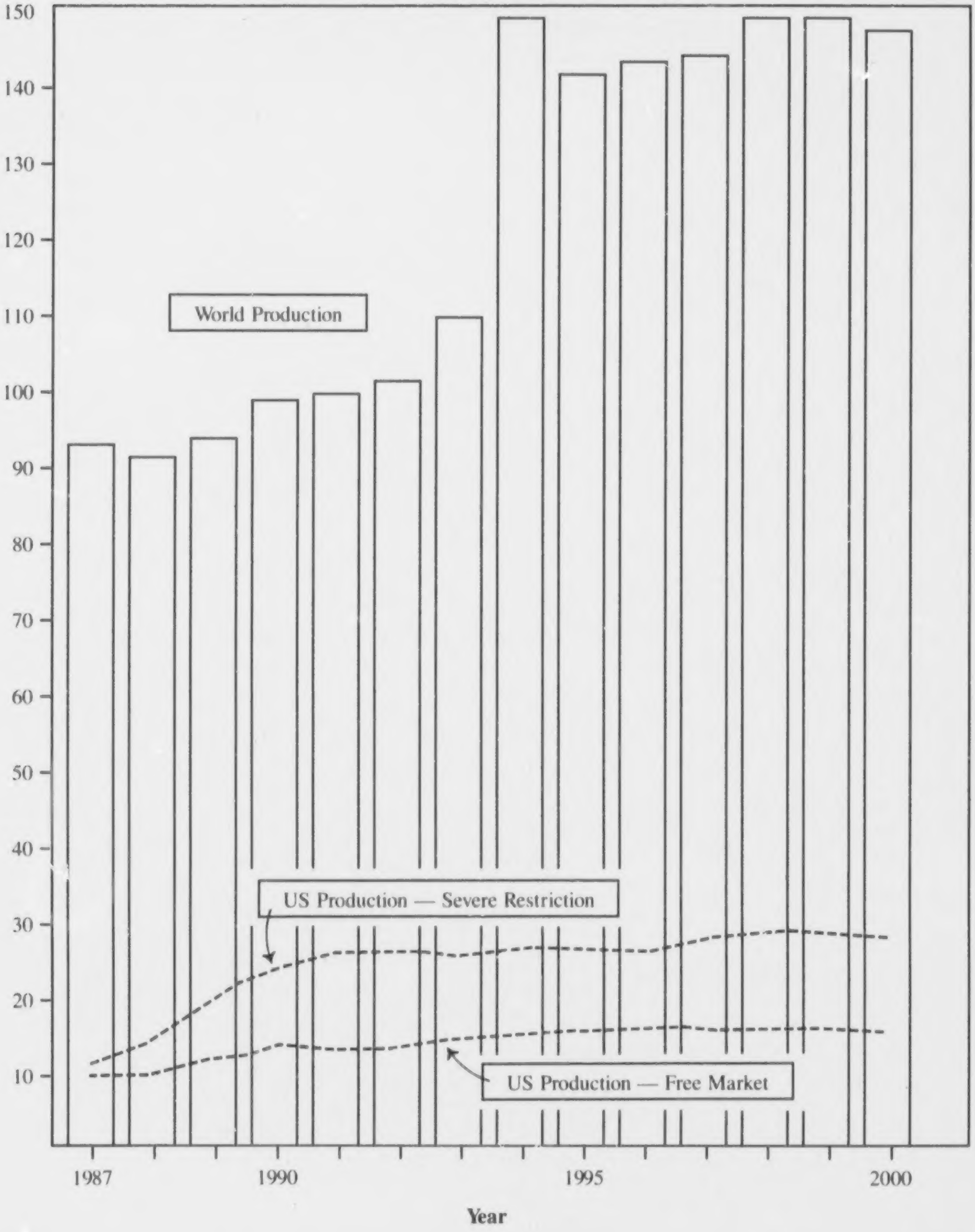


© NUEXCO 1987

ANALYSIS & COMMENTARY

Figure 5

WORLD AND US PRODUCTION FORECASTS



©NUEXCO 1987

World excess inventory is forecast to diminish to zero by about 1993. Uncommitted uranium supply increases steadily through 2000, with increments above a free market condition for both moderate and severe US market restrictions.

Under several restricted market scenarios, US production shows an increasing degree of stimulation as the level of restriction is increased above 50 percent, and is additionally stimulated depending on whether grandfathering of existing contracts is denied under a given restriction level. No stimulation is projected for a 50-percent restriction with full grandfathering. However, a 75-percent restriction, with no grandfathering allowed, is projected to require almost 200 million pounds U_3O_8 additional US production by 2000, versus only about 120 million pounds with grandfathering allowed.

©NUEXCO 1987

AUSTRALIA

The Australian federal elections on July 11, 1987, resulted in the Australian Labour Party (ALP) being returned to power with a majority of 24 seats in the House of Representatives. The ALP also gained some seats in the Senate but will not have an absolute majority, leaving the Australian Democrats holding the balance of power, as was the case in the previous Parliament.

The ALP campaign was based on the premise that Australia had overcome the worst of its economic problems and that it would be unwise for the electorate to vote the ALP out of office before it had completed the task of restructuring Australia's economy. As major achievements during its term of office, the ALP emphasized the improved trends in the balance-of-payment deficit, reduced budget deficit, lower unemployment figures, and the success of the "income and prices accord" in moderating wage increases with less industrial discord.

The Liberal Party, the main opposition party, based its campaign largely on criticism of the government's economic policies (high interest rates, unemployment, high inflation and overseas debt) and proposed substantial reductions in personal income tax rates (a top rate of 38 percent versus the government's previously announced top marginal rate of 49 percent), as an inducement for people to work harder and thereby turn Australia's economic situation around. The tax cuts would be paid by reducing government expenditures by some 16 percent over a three-year period.

The ALP did not propose any new major policy initiatives outside the social welfare area during its campaign. However, the new Labour government has announced a substantial reorganization of the federal bureaucracy in Canberra (which the Liberals also proposed). The number of government departments is to be reduced from 28 to 17, while the number of ministers will be increased from 17 to 30, through the creation of a number of "junior ministers" (all elected politicians in accordance with the Westminster system), who will be responsible for specific areas of a cabinet minister's portfolio or will assist the latter over a range of functions. This is expected to trim the bureaucracy by some 3,000 employees (mainly through attrition) and lead to annual cost savings of about A$96 million.

In the reorganization of departments, the Department of Trade will virtually disappear and its functions relating to export services (including "Austrade") and the marketing of manufactured goods will be taken over by the existing Department of Industry, Technology and Commerce, which will also be responsible for nuclear science and technology.

Most of the remaining functions of the old Trade Department will be combined with Foreign Affairs to form the Department of Foreign Affairs and Trade. This Department will be responsible for external multilateral and bilateral relations and overseas information services.

The present Resources and Energy Department will be combined with the Primary Industries Department to form a new Department of Primary Industry and Energy. This will take over the present functions of the two existing departments, as well as commodity marketing, including the existing government administrative controls relating to uranium sales and exports previously handled by the Department of Trade.

Until the restructuring is complete, it will not be clear which department will have the prime responsibility for uranium export matters. There is no indication at present of any significant changes in the government's policies on uranium mine development and exports.

Industrial Relations in the Australian Uranium Mining Industry

The current phase of Australia's uranium mining industry started with the re-opening of the Mary Kathleen Uranium Mine in North Queensland in the mid-1970s. Queensland Mines then commissioned its Nabarlek Mine in 1980, followed by Energy Resources of Australia's Ranger Mine in 1981. The latter mines are located in the Northern Territory.

The late 1970s to early 1980s was a period of intense activity by the anti-uranium movement, which had the support of several major trade unions involved in key areas such as rail transportation, shipping and stevedoring. This period was a difficult one for the mining companies which normally made their concentrate shipments through the ports of Brisbane and Darwin. Alternative transportation arrangements, such as air freighting, had to be made for some shipments to meet delivery commitments.

The principal trade union body, the Australian Council of Trade Unions (ACTU) is nominally opposed to the mining and export of uranium so long as perceived problems relating to non-proliferation and nuclear waste disposal remain unresolved. However, not all trade unions associated with the mining industry subscribe to the ACTU policy which, in any event, has adapted to the government's policy of limited uranium mine development.

Following the success of the ALP in the 1983 federal elections and the subsequent inquiry into the uranium industry by the Australian Science and Technology Council, the government decided that no new uranium mines would be permitted, apart from the Olympic Dam project in South Australia. Since the closure of the Mary Kathleen mine in 1982, and with the Nabarlek operations expected to cease

©NUEXCO 1987

next year, future uranium production in Australia will be limited to the one remaining Northern Territory producer and the new multi-mineral mine to be opened next year at Olympic Dam, unless present government policy is changed.

Since the present uranium policy was announced, the industry has settled down and anti-uranium activity is no longer considered a significant threat to scheduled uranium shipments. In early June, for example, what was probably the largest single shipment ever made by Energy Resources of Australia (ERA) moved unhindered through the port of Darwin.

Labor relations in the uranium mining industry should be viewed in the context of the broad industrial situation in the Australian economy as a whole, although the mining industry has its own special problems and circumstances, largely due to the remoteness of most mining sites and the less stable work forces often found in those areas.

Industrial disputes, as measured in terms of working days lost, have been greatly reduced since the ALP federal government assumed power in 1983. Introduction of the income and prices accord shortly thereafter has enabled the government to obtain the cooperation of the trade union movement in implementing its employment and anti-inflation policies. The accord has played a pivotal role in restraining wage and price increases during a period of considerable economic stress. Real unit labor costs have fallen by about seven percent and industrial disputes to less than half of the average recorded under the previous government. There has been a substantial drop in lost time during the 1983-86 period compared with, for example, the difficult 1979-81 period.

It has been thought for some time that the existing centralized system of wage indexation in Australia (the adjustment of wages and salaries in line with movements of the Consumer Price Index) is no longer appropriate in the present economic climate. Consequently, at the National Wage Case hearing in March 1987, the government decided to introduce a new two-tier wage system which would aim to ensure that:

1. Increases in nominal labor costs are reasonable and in line with the country's economic goals;
2. Efforts are made to increase efficiency and productivity at the industry and enterprise level; and
3. Protection is afforded to lower-paid workers.

In handing down its decision, the Australian Conciliation and Arbitration Commission decided to award a flat A$10 per week increase under the first tier, with the possibility of a further increase not exceeding a wage equivalent of 1.5 percent to be considered in October 1987. A four percent ceiling on wage and salary increases is provided under the second tier, which is aimed at achieving a consensus between the parties with respect to productivity and efficiency improvements, such as changed work and management practices and a reduction in demarcation barriers.

The introduction of the two-tier wage fixing system and other decisions made at the national wage case hearings will provide increased flexibility for future wage-fixing negotiations. Both unions and employers generally support the new system, which is expected to lead to further improvements in industrial relations and harmony throughout Australia. The uranium mining industry should benefit accordingly.

SOUTH AFRICA

Second-quarter uranium output from Chamber of Mines producers totaled 2,555,000 pounds U_3O_8, a decline of 5.9 percent from the first quarter of 1987 (Table 2). Substantial drops in output from Buffelsfontein (a 10-percent drop), Freegold (an 11-percent drop), ERGO (a 10-percent drop) and Western Areas (an 18-percent drop) accounted for much of the overall decline. Of the other Chamber of Mines producers, only Driefontein Consolidated, Harmony and Stilfontein (Chemwes) avoided a decrease in production.

The fall in output at Randfontein and Western Areas was the result of lower tonnage treated due to strikes and labor disruptions. The decline at Buffelsfontein was caused by a more than 20 percent drop in yield. Freegold and Vaal Reefs both reported lower tonnages of ore treated in the second quarter.

As one example of the South African producers' view of the uranium market over the past year, Mr. E. P. Gush, President of the Chamber of Mines of South Africa, made the following remarks in his Presidential Address, delivered on June 23, 1987:

"The South African uranium producers faced an unusually difficult year, with the continued strong buyer's market coupled with the introduction of mandatory sanctions by the Legislature of the United States. The passing of the Comprehensive Anti-Apartheid Act of 1986 in July of that year imposed a prohibition on the importation of South African uranium oxide, U_3O_8, into the USA with effect from 31 December, 1986. A subsequent administrative ruling permitted, under certain conditions, the importation of South African uranium for processing and re-export for use by third parties. This interim United States Treasury Department ruling is effective until 1 July, 1987 to allow comment on the ruling and a decision on policy after that date.

"These actions represent the overt face of uranium sanctions. Also troublesome are the covert sanctions imposed without formal legal basis in other areas, notably in Japan and the European Community, which severely inhibit the contracting for new business. These restrictions have to date had no immediate adverse effect upon our existing long-term contracts, the traditional form of our business, nor have they noticeably affected new long-term business, which, irrespective of these artificial constraints, has not been forthcoming in the short term in any event in view of the current weak conditions prevailing in that market.

"It is therefore interesting to observe that during the year under review, uranium disposals increased, partly as a result of some long-term contract deliveries being brought forward. It is hoped that the restrictive political climate under which the South African uranium industry is currently forced to operate will gradually be ameliorated as substantive progress is made on the domestic political front. This development, coupled with early signs of a modest recovery in the uranium market could set the stage for the continued viability of the South African uranium industry in the late 1980s, early 1990s."

Table 2

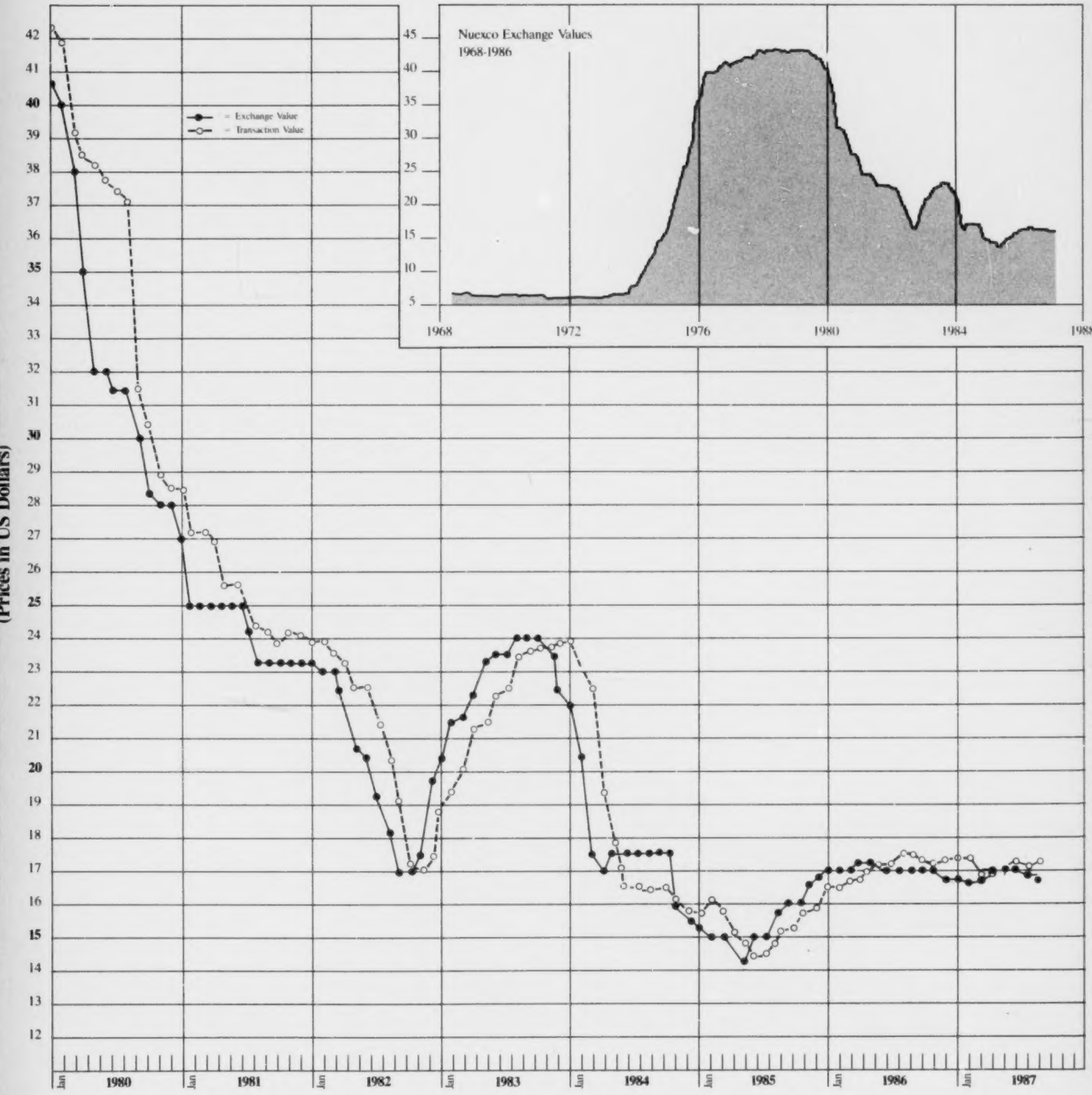
REPUBLIC OF SOUTH AFRICA
RECENT URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	Third Quarter 1986	Fourth Quarter 1986	First Quarter 1987	Second Quarter 1987	Percent Change[2]
Buffelsfontein	362	302	271	245	−9.6
Driefontein Consolidated	46	43	41	41	0
ERGO[3]	79	86	88	79	−10.2
Freegold[4]	279	266	275	245	−10.9
Harmony	171	116	102	103	+1.0
Hartebeestfontein	267	257	242	231	−4.5
Randfontein	304	356	314	297	−5.4
Stilfontein (Chemwes)	141	226	228	234	+2.6
Vaal Reefs	1,107	997	1,025	977	−4.7
Western Areas	150	133	127	104	−18.1
TOTAL[5]	2,906	2,782	2,714	2,555	−5.9

[1] Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.
[2] Change in percent from the first quarter of 1987.
[3] ERGO = East Rand Gold and Uranium Company Ltd.
[4] Formerly Free State Joint Metallurgical Scheme
[5] Columns may not add due to rounding.

©NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	**16.75**					

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	**17.30**					

© NUEXCO 1987

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	**1.90**					

HISTORICAL UF_6 VALUES

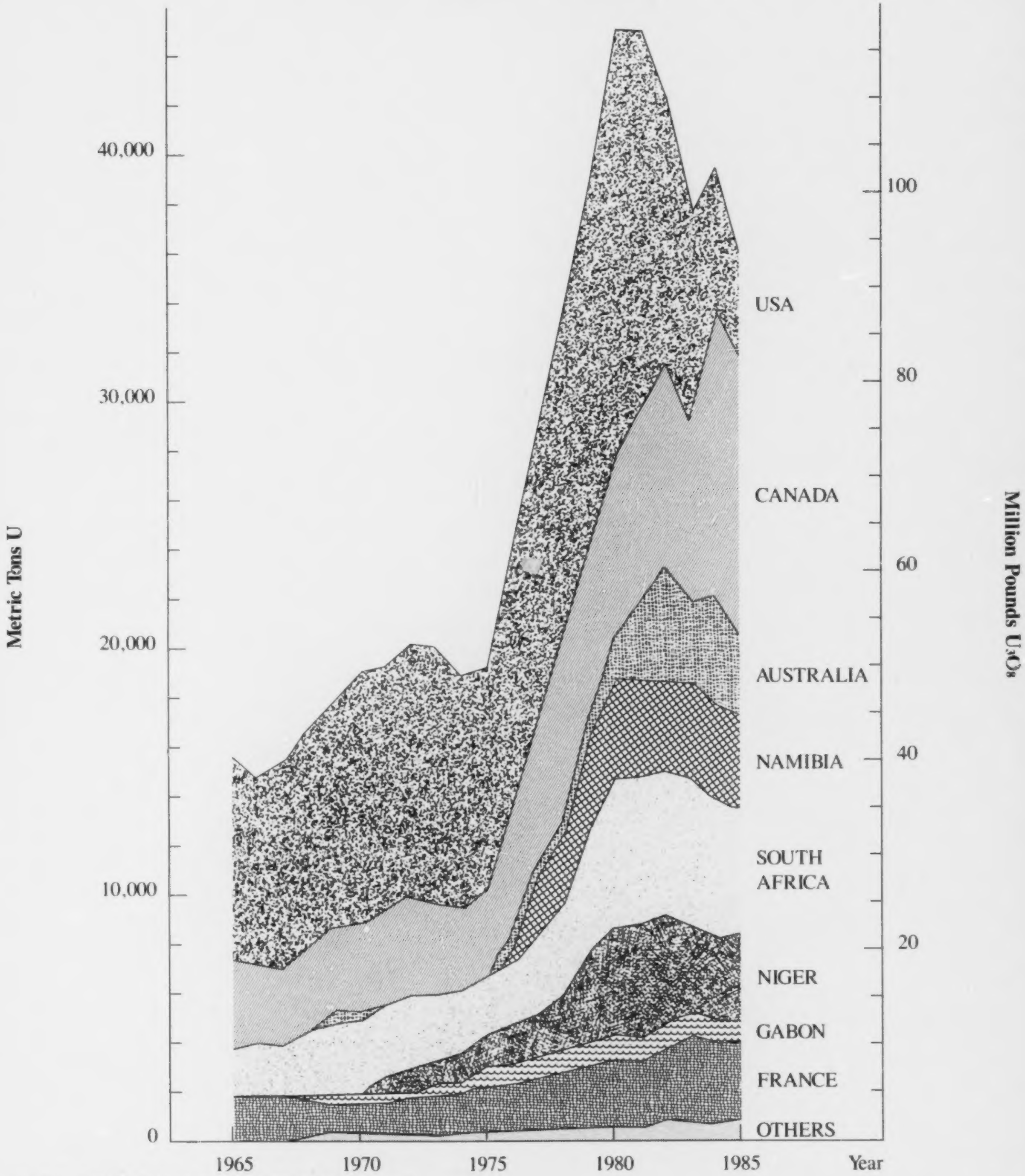
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	**47.50**					

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium (\$/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	\$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	\$28.15[5]	3.6	\$43.10	5.8
1981	38.5	32.6[5]	\$34.65[5]	6.6	\$32.90	4.4
1982	26.9	27.1	\$38.37	17.1	\$27.23[6]	6.2
1983	21.2	24.2	\$38.21	8.2	\$26.16	3.3
1984	14.9	22.5	\$32.65	12.5	\$21.86	2.2
1985	11.3	21.7	\$31.43	11.7	\$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2]	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1976 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
1984 Avg.	133.6	95.3	194.1
1985 Ave.	142.6	100.0[4]	203.2
1986 Avg.	155.5	104.9[4]R	213.7
Jan 1986	—	109.5R	211.2
Feb 1986	—	108.7	211.2
Mar 1986	150.5	99.4R	211.2
Apr 1986	—	94.2R	211.2
May 1986	—	93.5	211.2
Jun 1986	153.0	95.6R	211.2
Jul 1986	—	97.9R	216.0
Aug 1986	—	98.1R	216.0
Sep 1986	157.0	105.5R	216.0
Oct 1986	—	106.0R	216.1
Nov 1986	—	105.0R	216.3
Dec 1986	161.5	105.4R	216.2
Jan 1987	—	106.3R	216.2
Feb 1987	—	109.1R	216.5
Mar 1987	164.7	108.5P	217.0
Apr 1987	—	108.4P	—

P = Preliminary R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0).

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index is 1968/1069 = 100 for years 1975-1983, and 1984/1985 = 100 for all subsequent data.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Basis is 1975 = 100 for years 1975-1978, and 1976 = 100 for all subsequent data.

[4] Annual averages are for financial year ending June 30.

[5] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

©NUEXCO 1987

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan 1987	120.0	19.53R	16.93R	16.01R	13.06	12.58R	12.89R
Feb 1987	119.8	20.33	17.20R	16.21R	13.01	12.66	13.11R
Mar 1987	120.3	20.04	17.14R	16.15R	13.57	12.58	13.02R
Apr 1987	121.1	20.47	17.38R	16.26R	13.75R	11.99R	13.27R
May 1987	121.7P	20.50P	17.30P	16.13P	14.18P	11.96P	13.32P

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8] Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.88	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.76	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	741,032	585,461
Mar	1987	88.17	197.1	255.0	239.6	—	—
Apr	1987	—	—	258.2	242.5	—	—
May	1987	—	—	261.2	243.6	—	—
Jun	1987	—	—	263.1	—	—	—

P = Preliminary   R = Revised since last month

---

[1] Chamber of Mines of South Africa, Johannesburg; "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria; "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

UNITED STATES

	Producer Price Index[1]				Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.41R	13.68R	11.87R	9.58R
Feb 1986	318.9	304.4	327.5	—	13.46R	13.80R	11.83R	9.57R
Mar 1986	314.0	300.3	326.0	113.5	13.41R	13.91R	11.80R	9.60R
Apr 1986	311.6	298.2	325.3	—	13.47R	13.89R	11.84R	9.60R
May 1986	311.6	299.2	326.3	—	13.40R	13.79	11.90R	9.63R
Jun 1986	311.8	299.0	327.9	114.2	13.50R	13.50R	11.95R	9.59R
Jul 1986	308.5	297.4	328.0	—	13.33R	13.30R	12.05R	9.67R
Aug 1986	307.9	297.2	328.6	—	12.96R	13.13R	11.99	9.64R
Sep 1986	308.7	297.5	330.2	115.0	13.04R	13.28R	12.03	9.70R
Oct 1986	309.6	298.4	330.5	—	12.85R	13.16R	12.08	9.67R
Nov 1986	309.8	298.7	330.8	—	12.75R	13.14R	12.17R	9.73R
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.03R	12.20	9.82R
Jan 1987	313.6	300.9	333.1	—	12.94R	12.98R	12.18R	9.84R
Feb 1987	314.9R	302.2R	334.4	—	12.99R	12.83R	12.21R	9.84R
Mar 1987	315.8	302.8	335.9	116.2	13.04R	12.79R	12.24R	9.84R
Apr 1987	317.4	305.1	337.7	—	13.16R	12.90R	12.30R	9.82R
May 1987	318.6	307.3	338.7	—	13.00P	12.92P	12.30R	9.83R
Jun 1987	320.2	308.5	340.1	117.2	—	—	12.24P	9.82P

P = Preliminary   R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 to April 1985 are adjusted to the March 1980 benchmark. Data for January 1986 and beyond are adjusted to the March 1986 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.

Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.

Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.

Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR

- B6800-1 A
9/16/87

NUEXCO

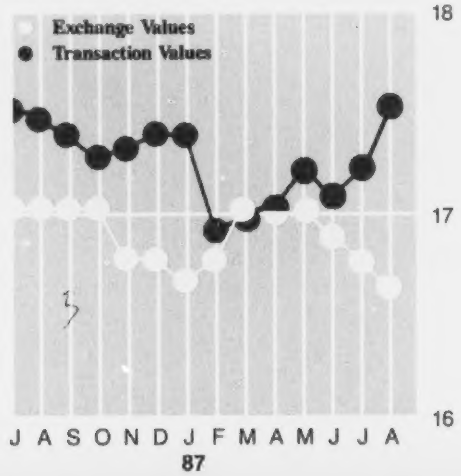
Monthly Report

September 1987 Number 229

A National Strategy for the US Nuclear Industry 13

Trends in US Uranium Mine Productivity 21

Market Implications for Uranium Suppliers 29



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-[illegible]821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

CHIEF EXECUTIVE OFFICER — Charles H. Peterson

NUEXCO TRADING CORPORATION

President	Earl E. Hoellen, Jr.
Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

NUEXCO INFORMATION SERVICES CORPORATION

President	R. Gene Clark

Support Services

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

Hans W. Vogt
(Switzerland)

Chris I. von Christierson
(South Africa)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 229
(All data as of August 31, 1987)

Exchange Value
$16.65, down $0.10

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month.The US Premium (relative to the Exchange Value) is $2.35, down $0.15 since last month.

UF_6 Value
$47.00, down $0.50

The **UF_6 Value** is **$47.75** per kilogram U as UF_6, down $0.50 since last month.The US Premium (relative to the UF_6 Value) is $6.00, down $0.50 since last month.

Transactions

Six recent natural uranium sales are reported, involving **1.6 million** pounds equivalent U_3O_8. All of the sales involved spot or near-term delivery, and four met the conditions for inclusion in the Transaction Value. Active spot and near-term **uranium supply** amounts to **3.7 million** pounds U_3O_8 equivalent, up 900 thousand pounds since last month. Active spot and near-term **uranium demand** totals **2.0 million** pounds, down 460 thousand pounds from last month. The spot and near-term **supply-demand ratio** increased to **1.8 to 1**.

Transaction Value
$17.55, up $0.25

The **Transaction Value** is $17.55 per pound U_3O_8, **up $0.25** since last month. The calculation includes transactions involving a total of 4.2 million pounds U_3O_8 and equivalent UF_6, of which 1.4 milion pounds are US-origin, and covers a period of 3 months.

Loan Rate
4%, up one percent

The **Loan Rate** is **4 percent** per annum, up one percent.

Conversion Value
$1.90, unchanged

The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 750 thousand pounds U as UF_6. Active demand totals 440 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

SWU Value for
delivery within
one year: $75,
unchanged

The **SWU Value** at .3% tails assay and for delivery within one year is **$75** per SWU, unchanged since last month. Two secondary market SWU transactions are reported.

* * *

Essay

Mr. J. R. Wolcott, former Chairman of Nuexco, argues in this essay that the US nuclear industry must attempt several changes if it is to reestablish itself in coming years. It must change existing concepts regarding nuclear plants and plant sites, and it must promote its inherent environmental advantages. To regain the industry's lost momentum, a new prototype construction program should be undertaken, to evaluate advanced technologies and develop new reactor plans.

Raw Materials

Since the mid-1960s, productivity factors in US uranium mines have varied considerably. This article compares mine productivity, production and employment in open-pit and underground mines during the period from 1967 to the present.

Analysis and
Commentary

Continued low spot and near-term prices in the uranium market have placed increased pressure on world uranium producers. Utilities have become both more price conscious and more sophisticated in their procurement programs, encouraging intense competition among suppliers. The keys to survival for producers will continue to be flexibility in terms and conditions of sales and low relative production costs.

© NUEXCO 1987

NUEXCO

NUEXCO REPORT 229 FIGURES OF THE MONTH (August 31, 1987)	This Month (Report 229)	Last Month (Report 228)	12 Months Ago (Report 217)
Exchange Value (US $ per pound U_3O_8 equivalent)	16.65	16.75	17.00
US Premium for the Exchange Value (US$ per pound U_3O_8)	2.35	2.50	—
UF_6 Value (US $ per kilogram U as UF_6)	47.00	47.50	48.00
US Premium for the UF_6 Value (US$ per kgU as UF_6)	6.00	6.50	—
Transaction Value (US $ per pound U_3O_8 equivalent)	17.55	17.30	17.45
Loan Rate (Per Annum)	4%	3%	4%
Conversion Value (US $ per pound U as UF_6)	1.90	1.90	1.90
Near-Term Uranium Supply[1] (millions of pounds U_3O_8)	3.7	2.8	4.2
Near-Term Uranium Demand[2] (millions of pounds U_3O_8)	2.0	2.5	1.5
Near-Term Supply-Demand Ratio	1.8	1.1	2.9
Recent Uranium Sales:[3]			
Number of Transactions	6	8	5
Quantity of Material (Millions of pounds U_3O_8 equivalent)	1.6	1.8	1.5
Nuexco SWU Value:			
at 0.3 tails assay and delivery within one year (US $ per SWU)	75	75	78
US DOE SWU Prices:			
USEC	119.00[4]	119.00[4]	125.00[5]
AFC	153.00[6]	153.00[6]	153.00[6]
Requirements	157.00[6]	157.00[6]	157.00[6]
Incentive Price	90.00[7]	90.00[7]	—
Market Value of Enriched UF_6[8]: (US $ per kgU as UF_6)			
2.5 w/o U_{235}	446	447	458
3.0 w/o U_{235}	570	572	586
3.5 w/o U_{235}	697	699	717
4.0 w/o U_{235}	825	827	849

---

[1] Active inquiries to sell, for delivery within 12 months after contract signing.

[2] Active inquiries to purchase, for delivery within 12 months after contract signing.

[3] Uranium sales only; does not include loans, conversion, or SWU transactions.

[4] Effective since 10/1/85.

[5] Effective since 10/1/86.

[6] Effective since 10/1/85.

[7] Effective since 10/1/86, for up to 30% of annual requirements.

[8] Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used the Nuexco SWU Value for DOE origin and delivery by the end of FY 86. As of 12/31/85, calculations use the SWU Value for delivery within one year.

© NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

September 1987 No. 229

R. GENE CLARK, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Natural Uranium and Conversion 1
Enriched Uranium and SWU 2

CURRENT MARKET DATA

Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

ESSAY

A National Strategy for Nuclear Power in the USA 13

RAW MATERIALS

US Uranium Mine Productivity 21

ANALYSIS AND COMMENTARY

The Uranium Market: Implications for Suppliers 29

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 33
Historical Exchange Values and Transaction Values 34
Historical Conversion Values and UF_6 Values 35
Graph of World Uranium Production 36
US Uranium Marketing Activities Statistics 37
Volume and Price of Uranium Deliveries to the European Community . . 38

GOVERNMENT STATISTICS

Australia 39
Canada 40
South Africa 41
United States 42

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein.

© 1987 Nuexco Services Ltd.

ISSN 0742-4582

NUEXCO

August 31, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.65**/lb. U_3O_8	3,730	2,025
US Premium	**$2.35**		
UF_6 VALUE	**$47.00**/kgU		
US Premium	**$6.00**		
CONVERSION VALUE	**$1.90**/lb. U as UF_6	750	440
SWU VALUE			
0.3 tails assay: delivery within one year	**$75/SWU**		
LOAN RATE	**4**%/annum	600	100

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.55**	**4.2**	**19**	**3**

[1] Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Values** represent Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
b. At least ten transactions;
c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

7. **The US Premium** is Nuexco's judgment of the incremental price (relative to the Exchange Value or UF_6 Value, as applicable) at which transactions for significant quantities of natural uranium could be concluded as of the date indicated, if the buyer will accept only US-origin.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:

a. Data from recently completed transactions.
b. Data from pending transactions.
c. Firm bids to buy or borrow, and firm offers to sell or lend.
d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed awillingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.

2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

© NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of August 31, 1987)

The **Exchange Value** is **$16.65** per pound U_3O_8, down $0.10 since last month. **US-origin** uranium is commanding a **premium** (relative to the Exchange Value) of **$2.35** per pound U_3O_8 (down $0.15). **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals 3,730,000 pounds U_3O_8 equivalent, up 900,000 pounds since last month. The corresponding figure for **active demand** is 2,025,000 pounds, down 460,000 pounds. The spot and near-term **supply-demand** ratio increased to 1.8 to 1.

The *Current Market Data* section of this Report lists **six** natural uranium sales, totaling **1.6 million pounds** U_3O_8 equivalent.

The **Transaction Value** is **$17.55** per pound U_3O_8, up $0.25 since last month. The calculation extends over a 3-month period and includes 19 transactions involving 4.2 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$47.00** per kilogram U in UF_6, down $0.50 since last month. US-origin UF_6 is commanding a **premium** (relative to the UF_6 Value) of $6.00 per kilogram U in the form of UF_6, down $0.50. Three transactions involving UF_6 are reported, totaling approximately 1.1 million pounds equivalent U_3O_8. Demand for UF_6 remains weak.

The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active supply of secondary market conversion services totals 750 thousand pounds U as UF_6. Active demand totals 440 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **4 percent** per annum, up one percentage point since last month.

* * *

The Exchange Value declined $0.10 this month to $16.65 per pound U_3O_8, and the Premium (relative to the Exchange Value) for US-origin slipped $0.15 to $2.35 per pound U_3O_8, reflecting a slight softening in the markets for both US and non-US-origin uranium. In the USA, some demand exists for US-origin material, but most buyers have been waiting for further developments in the US Producers vs. DOE lawsuit before making firm procurement plans.

As of September 3, the US Tenth Circuit Court of Appeals had not acted on DOE's July 23, 1987 emergency motion requesting a stay of the July 20 decision upholding Judge Carrigan's June 1986 ruling in favor of the producers. Meanwhile, DOE has continued to enrich non-US-origin uranium for use in US reactors, asserting that earlier Congressional action essentially gives DOE the right to enrich non-US-origin feed until the matter is finally resolved by the US Supreme Court. The stated basis for this position is language contained in the appropriations bill funding DOE for Fiscal Year 1987, in which the Conference Committee Report described a resolution to the lawsuit as "a decision by the Court of Appeals or the Supreme Court, should *certiorari* be granted." DOE refers to this language as being tatamount to a "legislative stay."

The Court of Appeals mandate of its July 20, 1987 decision will take effect on September 4, 45 days after the decision, unless prior to that date the Court grants DOE's motion for stay or unless the US Supreme Court should grant a stay prior to that date. As of September 3, DOE had not requested such a stay from the Supreme Court. Upon the mandate becoming effective, DOE is obliged thereafter to follow Judge Carrigan's June 1986 order. Whether DOE will conduct its enrichment activities in conformity with the court's decision, or continue to assert that it has a legislative stay and therefore is excused from the mandate, is unknown at this time. Many observers anticipate that the Appeals Court will rule on DOE's emergency motion, either granting or denying the stay, but the Court need not do so and can simply let the mandate become effective on September 4 without further action.

Although following last month's Appeals Court ruling DOE indicated that it was preparing to file petition for *writ of certiorari* to the Supreme Court for a review of the case, DOE has not as yet filed its petition. Since the granting of a stay by the Appeals Court might be presumed to be at least partially based on DOE's intent to take the case to the Supreme Court, DOE's failure to follow up on its announced course of action is at least curious, and could influence the Appeals Court's deliberation on the stay request.

Numerous motions and briefs have been filed in the Appeals Court by, and in support of, both sides in the case with respect to the granting of the stay and the effectiveness presently of the District Court's decision. The states of Colorado, New Mexico, Nevada, Utah, and Wyoming have

© NUEXCO 1987

filed amici curiae briefs, opposing DOE's "legislative stay" interpretation, and also reminding the court that the House of Representatives had passed an NRC appropriations bill for FY 1988 and 1989 that authorized the NRC to use the funds to implement sections 161(b) and 161(p) of the Atomic Energy Act, which would enable the NRC and DOE jointly to apply conditions to nuclear plant licenses, restricting utilities' uranium purchases to US-origin. And in a letter to the Tenth Circuit Court of Appeals, lawyers for the plaintiffs (the Producers) protested DOE's refusal to comply with the court decision, saying "In effect, the government has given itself a stay of this Court's Order by its self-serving interpretation of legislative action on a continuing appropriations bill."

If DOE's motion for stay is denied or the Appeals Court takes no action by September 4, DOE may request a stay of Judge Carrigan's order from Justice Byron White (or other available Justice) of the Supreme Court. Whether DOE will do so may depend on how enforcement proceedings transpire in Judge Carrigan's court. In the interim, DOE has until October to file its petition for *writ of certiorari*. Realistically there are many procedural strategies that may yet be played out by both sides and it will probably be at least several months before the issue is resolved. Meanwhile, it is very doubtful that Congress will be able in the near term to agree upon legislation that will resolve the matter. Until DOE's legal responsibilities with respect to the status of a restriction on enrichment of non-US-origin uranium for use in US reactors are clarified, the market for US-origin uranium will continue to reflect buyers' uncertainty over possible restriction levels.

* * *

Three spot and near-term U_3O_8 transactions are reported this month, involving approximately 500 thousand pounds. All of those transactions involved US-origin uranium; one of the transactions for a significant quantity of material occurred earlier this summer, and the other two involved August purchases of smaller quantities of material.

Three UF_6 transactions also are reported, involving 1.1 million pounds U_3O_8 equivalent. One of those transactions involved a US utility purchasing non-US-origin UF_6 for virtually immediate delivery. Believing that restrictions on the use of non-US-origin uranium will result from the current litigation between the US producers and DOE, at least some US utilities are considering accelerating their enrichment schedules. Even with DOE concurrence, such transactions require the availability of non-US-origin feed on extremely short notice to minimize the risk of holding such feed, which could not be utilized if restrictions were suddenly imposed. This potential demand suggests that UF_6 prices for immediate delivery could well be somewhat higher than prices for deliveries further out in time.

Since February 1987, the Transaction Value has shown a steady overall rise. The Transaction Value is a volume-weighted average of actual prices in recent transactions and is not differentiated according to origin of uranium. Because transactions involving US-origin typically carry higher prices, since April 1987 the Transaction Value and the Exchange Value have diverged and the Transaction Value is now about 5-percent higher than the Exchange Value.

* * *

The Loan Rate increased this month, primarily due to expectations that short-term loans could create possibilities for US utilities either to deliver non-US-origin uranium to DOE before being restricted from doing so, or to better manage short-term shortages in the event of a restriction. The rise in the Loan Rate is linked to an increase in this potential borrower interest, although no loan transactions are reported this month.

* * *

The Conversion Value is unchanged this month, and much of the secondary market demand, which is driven by a preference for immediate purchase and delivery of UF_6 rather than for purchase of U_3O_8 to be placed in inventory, has now dissipated.

ENRICHED URANIUM AND SWU

The SWU Value is unchanged this month, at $75 per SWU. Firm demand for secondary market SWU continues to be weak. Although a number of US utilities have solicited verbal offers for non-DOE SWU for short-term delivery, those actions seem to be due more to the evaluating of options should DOE be unable to enrich their non-US-origin feed, than to a firm demand for SWU.

The SWU Value of $75 is a representative price for a highly segmented market, in which prices being offered by sellers vary widely, depending on SWU origin, delivery location, and the flexibility of enrichment assay offered. At the low end of the price range are the prices being quoted by the non-western-origin SWU suppliers. These sellers are forced to discount their SWU below other sellers due to western utility buyers' perceived risk of non-supply. These

© NUEXCO 1987

sellers also tend to have restrictive feed delivery and origin requirements.

Near the middle of the range are sellers of either DOE-origin SWU commitments, whose buyers (if they are US utilities) run the risk of having to deliver high-priced US-origin feed for enrichment, or sellers of enriched uranium inventory, who are limited by constraints concerning location or product assay. Buyers of enriched inventory will usually have to buy additional higher-priced upgrade SWU to re-enrich the material to the desired assays.

At the upper end of the price spectrum are sellers of excess Eurodif or Urenco SWU commitments. These sellers can offer flexibility both in assay and in delivery location. Most such sellers are European, and the weakness of the US dollar relative to the European currencies has tended to raise sellers' offering prices for such SWU in US dollars.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**
Australia (dollar)	23.41	23.99	27.91	60.86	62.36	72.55
Belgium (comm. franc)	627.59	642.75	720.03	1,632	1,671	1,872
Canada (dollar)	21.94	22.32	23.66	57.05	58.01	61.51
EEC (ecu)	14.61	14.99	16.57	37.99	38.97	43.09
Finland (markka)	73.25	75.38	83.50	190.44	195.98	217.07
France (franc)	100.73	103.27	114.25	261.86	268.47	297.02
FRG (mark)	30.16	31.06	34.86	78.42	80.75	90.64
Italy (lira)	21,845	22,477	24,021	56,791	58,436	62,450
Japan (yen)	2,363	2,503	2,651	6,144	6,506	6,893
Netherlands (guilder)	33.99	34.98	39.26	88.38	90.93	102.07
South Africa (rand)	33.91	34.72	43.93	88.16	90.25	114.20
Spain (peseta)	2,031	2,117	2,274	5,281	5,505	5,911
Sweden (krona)	106.19	108.27	117.57	276.06	281.49	305.64
Switzerland (franc)	24.85	25.74	28.13	64.61	66.91	73.12
UK (pound)	10.19	10.50	11.49	26.50	27.30	29.87
US (dollar)	16.65	16.75	17.00	43.29	43.55	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**
Australia (dollar)	24.68	24.77	28.64	64.15	64.41	74.47
Belgium (comm. franc)	661.52	663.85	739.09	1,720	1,726	1,921
Canada (dollar)	23.13	23.05	24.29	60.13	59.92	63.14
EEC (ecu)	15.40	15.48	17.01	40.04	40.25	44.23
Finland (markka)	77.21	77.86	85.71	200.73	202.41	222.82
France (franc)	106.17	106.66	117.27	276.02	277.29	304.88
FRG (mark)	31.79	32.08	35.79	82.66	83.40	93.04
Italy (lira)	23,025	23,215	24,657	59,861	60,354	64,104
Japan (yen)	2,491	2,585	2,721	6,476	6,720	7,075
Netherlands (guilder)	35.83	36.12	40.30	93.15	93.92	104.77
South Africa (rand)	35.74	35.85	45.09	92.92	93.21	117.22
Spain (peseta)	2,141	2,187	2,334	5,566	5,685	6,067
Sweden (krona)	111.93	111.83	120.68	290.98	290.73	313.74
Switzerland (franc)	26.19	26.58	28.87	68.10	69.11	75.06
UK (pound)	10.74	10.85	11.79	27.93	28.20	30.66
US (dollar)	17.55	17.30	17.45	45.63	44.98	45.37

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on August 31, 1987.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U as UF_6			per kg. U as UF_6		
Country (currency)	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**	**This Month (Aug 31, 1987)**	**Last Month (Jul 31, 1987)**	**12 Months Ago (Aug 31, 1986)**
Australia (dollar)	2.67	2.72	3.12	5.89	6.00	6.88
Belgium (comm. franc)	71.62	72.91	80.47	157.89	160.74	177.42
Canada (dollar)	2.50	2.53	2.64	5.52	5.58	5.83
EEC (ecu)	1.67	1.70	1.85	3.68	3.75	4.09
Finland (markka)	8.36	8.55	9.33	18.43	18.85	20.57
France (franc)	11.49	11.71	12.77	25.34	25.82	28.15
FRG (mark)	3.44	3.52	3.90	7.59	7.77	8.59
Italy (lira)	2,493	2,550	2,685	5,496	5,621	5,919
Japan (yen)	269.69	283.88	296.32	594.57	625.84	653.27
Netherlands (guilder)	3.88	3.97	4.39	8.55	8.75	9.67
South Africa (rand)	3.87	3.94	4.91	8.53	8.68	10.82
Spain (peseta)	231.79	240.17	254.11	511.01	529.49	560.22
Sweden (krona)	12.12	12.28	13.14	26.71	27.08	28.97
Switzerland (franc)	2.84	2.92	3.14	6.25	6.44	6.93
UK (pound)	1.16	1.19	1.28	2.56	2.63	2.83
US (dollar)	1.90	1.90	1.90	4.19	4.19	4.19

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	**SWU Value delivery within one year (Aug 31, 1987)**	**UF_6 Value per kg.U in UF_6 This Month (Aug 31, 1987)**	**UF_6 Value per kg.U in UF_6 Last Month (July 31, 1987)**
Australia (dollar)	105.46	66.08	68.02
Belgium (comm. franc)	2,827	1,772	1,823
Canada (dollar)	98.84	61.93	63.28
EEC (ecu)	65.83	41.25	42.50
Finland (markka)	329.96	206.77	213.77
France (franc)	453.72	284.33	292.84
FRG (mark)	135.87	85.14	88.07
Italy (lira)	98,399	61,664	63,741
Japan (yen)	10,646	6,671	7,097
Netherlands (guilder)	153.12	95.95	99.18
South Africa (rand)	152.75	95.72	98.44
Spain (peseta)	9,150	5,734	6,004
Sweden (krona)	478.32	299.74	307.04
Switzerland (franc)	111.94	70.14	72.98
UK (pound)	45.91	28.77	29.78
US (dollar)	75.00	47.00	47.50

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on August 31, 1987.

©NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4135	1987	101-300	R[6]	Producer	R[6]	US-Origin
4136	1987	301-600	98-102	Producer	Utility	UF_6
4144	1988	101-300	98-102	Intermediary	Utility	US-Origin UF_6
4146	1989	301-600	108-112	R[6]	Utility	UF_6
4147	1987	less than 50	98-102	Producer	Intermediary	US-Origin
4148	1987	101-300	103-107	Intermediary	Utility	US-Origin

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
4131	1987	101-300	R[6]	Intermediary	R[6]	

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value).

[3] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[4] Prices are usually normalized to 0.3 % tails assay.

[5] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the discounts, not the ratio of the prices.

[6] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWU)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4140	1988	101-300	R[5]	R[5]	Utility	USSR	
4142	1987	less than 50	93-97	Utility	Intermediary	DOE	

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.30% tails assay.

[4] Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts from a reference price(e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted price, not on the reference price.

[5] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

©NUEXCO 1987

CURRENT MARKET DATA

URANIUM SUPPLY
(August 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near -term[2]	Intermediate or Long-term	Remarks
Available for Sale: **ACTIVE**			
87-1002	270	—	
87-1014A	720	—	UF_6
87-1022	40	—	
87-1023	500	500 per year	1988-90
87-1053*	100	500	1988 on
87-1061*	500	500 per year	1988
87-1079*	100	—	
87-1091*	1,000	1,000	UF_6
87-1097*	500	—	
87-1001	—	400 per year	1989 on
87-1005	—	400 per year	1988-95
87-1068	—	325	1988
TOTAL:	3,730		
INACTIVE			
87-1017	1,000	—	
87-1047*	500	—	UF_6
87-1055*	250	300 per year	1988-93
87-1059	120	—	UF_6
87-1019	—	600 per year	1988-91
87-1025*	—	250 per year	1988 on
87-1062*	—	100 per year	1988-89
TOTAL:	1,870		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2168, 2297, 2764B, 3123, 3168.

©NUEXCO 1987

URANIUM DEMAND
(August 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase: ACTIVE			
87-1030	175	—	
87-1070*	600	—	
87-1078*	200	—	
87-1082*	200	—	
87-1092*	200	—	U_3O_8 or UF_6
87-1095*	650	—	UF_6
87-1013	—	1,200 per year	1990-95
87-1021	—	675 per year	1992 on
87-1049	—	700 per year	1989, 91, 94, 96
TOTAL:	2,025		
INACTIVE			
87-1007	150	—	
87-1040	300	300	1989
87-1048*	50	—	
87-1057*	250	—	UF_6
87-1073*	800	—	
TOTAL:	1,550		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 2893C, 2962, 3137, 3152, 3220.

©NUEXCO 1987

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(August 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: **ACTIVE**			
87-1008	750	750	
TOTAL:	750	750	
INACTIVE			
1084C	120	—	
TOTAL:	120		
Inquiries to Purchase: **ACTIVE**			
87-1072	440	—	
TOTAL:	440		

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 3165.

©NUEXCO 1987

LOAN SUPPLY AND DEMAND
(August 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
87-1064	600	—	
TOTAL:	600		
INACTIVE			
87-1012	2,000	—	
87-1031*	1,000	—	
87-1033	1,000	—	
87-1071*	1,000	—	UF_6
TOTAL:	5,000		
Inquiries to Borrow			
ACTIVE			
87-1098*	100	—	UF_6
TOTAL:	100		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: 1938, 2036, 2909.

© NUEXCO 1987

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(August 31, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWU) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
1096	150	—	1988
1068*	100	—	1988
TOTAL:	250		
INACTIVE			
87-1004	55	—	1987
87-1058	50	—	1987-88
87-1059	25	—	
TOTAL:	130		
Inquiries to Purchase:			
ACTIVE			
87-1024	25	—	1988
87-1087*	15	—	1988
TOTAL:	40		
INACTIVE			
87-1042	30	—	
87-1065*	150	—	1988
TOTAL:	180		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWU deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 3173, 3159, 3213.

©NUEXCO 1987

ESSAY

A NATIONAL STRATEGY FOR NUCLEAR POWER IN THE USA

By J. Robert Wolcott
Chairman, Nuexco/Concord International
Advisory Committee

Mr. Wolcott, the former Chairman of Nuexco, is now Chairman of the Nuexco/Concord International Advisory Committee. Mr. Wolcott's views, as outlined in this essay, are set forth to stimulate thought and discussion, and do not necessarily represent those of Nuexco.

In this essay, Mr. Wolcott presents four main points that are substantial departures from most current thought in the nuclear industry.

First, efforts to change the existing regulatory system will have only limited benefits; the industry must accommodate the market and face the deeply-rooted psychological patterns and social conditions that are not likely to quickly change. New conceptual approaches, both to nuclear plants and to plant siting, are needed to better align the industry with today's electricity market, and the markets as they will probably be in the future.

Second, nuclear power must capitalize on its greatest asset, which is its inherent environmental advantage over most other generating technologies. Focusing public attention on the need for additional electric power supplies and on the advantages of nuclear fuel supply security have not changed public attitudes enough to bring about a resurgence of the US nuclear industry.

Third, if present trends continue, we should not expect renewed nuclear construction. But new construction is vital for many reasons. The best means of beginning new construction is through a prototype program, which would result in new standardized, licenseable light-water reactors and would evaluate newer technologies for possible use in the future.

Fourth, a realistic approach to the market would necessarily involve many changes in organization of the nuclear industry, including redefined roles for reactor vendors, government, and utilities.

Introduction

More than 30 years have passed since the beginning of commercial nuclear power in the USA. The first half of that period was largely a string of successes, while the second half has been largely a string of setbacks. After construction of more than 100 power plants, producing over 16 percent of the nation's power, expansion has stopped and no renewal of construction is in sight. What to do to revive the nuclear industry, and who should do it, are matters of national importance. Leadership in the field of nuclear power was once considered essential by the US government, among others. Nuclear power was an important instrument to achieve national technological and economic objectives.

For example, the Atoms For Peace Program, begun under the Eisenhower Administration, assumed that US leadership would be essential to control the proliferation of nuclear weapons. Policies were shaped accordingly. Within the past fifteen years, however, utilities and government in the USA have ceased new construction, terminated reprocessing, imposed unilateral political conditions on nuclear fuel supply, and are no longer working at the leading edge of most nuclear technologies. France and Japan are now supplying the driving forces that mean future leadership.

US electrical energy needs, growing 3 percent per year, will soon require as many as 15 to 30 large new electric power plants each year. Existing plants are aging and the rate of new construction is insufficient to provide replacements. Although a balance of excesses and shortfalls in regional capacity has allowed delaying new construction, much of the potential available from such an increase in utilization efficiency has now been used. The limitations of renewable sources are such that they cannot yet contribute in a major way. Environmental concerns over the use of fossil fuels are increasing. In short, the USA is postponing solutions to its imminent problems until some future date.

A widely accepted belief is that nuclear power will eventually be essential to the USA. A strategy is needed that will connect the US policy position with what will eventually allow a much greater utilization of nuclear energy. But such a strategy requires that we ask, and answer, many questions. What are the implications of the USA accepting a progressively declining world role in nuclear technology, in which the dominant leadership is assumed by others? Will nuclear power be seen as a solution to fossil power plant air pollution? Should the USA rely on present designs, siting concepts and regulatory approaches for the

©NUEXCO 1987

future? What is the US policy on standardization? Who will take the lead where government, industry, and the public are concerned? Answers to these questions are overdue.

New Conditions

When the nuclear industry began in the 1950s, it was supported by a non-hostile public attitude, a government fully ready to undertake nuclear programs for domestic and international reasons, utilities willing to participate, and businesses willing to invest. New power plants were generally welcomed by communities. Waste disposal was not an issue. It was an article of faith that scientists and engineers would solve whatever problems emerged from nuclear technology. All of that has changed, and any strategy for the revival of the US nuclear industry must grapple with those changes.

The most important change of the past 15 years has been the extreme politicization of energy. The oil crises, in particular, highlighted the impact of energy policies on national security, the economy, and foreign relations. Energy costs pitted consumers against producers and increased the government's role as an arbitrator. The newly discovered importance of energy technology and policy attracted increased interest from a whole range of academicians, philosophers, lawyers, media specialists, scientists, consumer advocates, and others. Various "experts" promoted solutions to energy-related problems ranging from the practical to the ridiculous, and most of the proposed solutions carried a strong political content. Politicization moved decision-making from the realm of economists, managers, and engineers, to the political arena. Tax incentives, regulations, and various types of self-interest became more important than simple economics.

Public acceptance has become a much more important consideration. The public now demands worry-free operation with safety assurances beyond those considered necessary on technical grounds. Shipments of radioactive materials, once carried out routinely, are increasingly resisted by communities and states. "Pro-environment" positions often gain widespread public and government support, even when scientific proof is lacking. Businessmen understand all too well the perils of ignoring the true market, which is always a combination of economic, technological, social and psychological factors.

The Forces of Deregulation

Twenty years ago each utility, with few exceptions, provided its own generation, transmission and distribution facilities within prescribed geographical areas. Conditions gradually changed as power plants were located near fuel sources (particularly fossil-fuel sources) and economies of scale encouraged large plants whose generating capabilities often exceeded the needs of production for a single area, and could be used to produce for another. Regional barriers which once existed began to weaken as utilities focused on integration and supply to larger markets than those which they had previously known.

At the same time, interest in the benefits of increased competition has been growing. The trend toward increased deregulation is shaping a modified incentive structure with a strong competitive emphasis. For example, Commonwealth Edison is proposing a separate generating company owning several nuclear plants. San Diego Gas and Electric announced its intention to concentrate on distribution and the purchase of bulk power from others. Bechtel proposed formation of an operating company to include nuclear plants owned by several utilities.

Separately-owned transmission lines are under consideration. Cogeneration facilities owned by industries other than utilities are providing power to certain users, and are increasing rapidly in importance. Numerous other small suppliers are seeking access to the power generation market. The forces favoring deregulation exist not only on an ideological level at the top of the federal government, but also at lower levels in the form of small-scale operators.

Deregulation need not apply evenly to generation, transmission, and distribution. The potential for competition is different with each. Bulk electricity can be sold competitively. Transmission may, or may not, be competitive, depending upon local circumstances, and regulation probably would be necessary to preclude "toll gate" monopolies. Competition for local distribution is probably impractical because duplicate facilities may be impractical, and regulation may continue much as it is. Separate incentive and regulatory structures would need to be designed for each segment of the electricity market, and operations to fit those structures would naturally evolve.

Such changes would not occur all at once, but rather would take place step by step in many separate utilities regulated by separate agencies of government. The pace

©NUEXCO 1987

will not appear revolutionary. Nevertheless, the cumulative impact by the end of the century will be substantial.

The Role of Government

Thirty years ago, when nuclear power's advancement was believed vital, the government organized for action. A Joint Committee for Atomic Energy (JCAE) was comprised of members of both houses of Congress, and the US Atomic Energy Commission (AEC) focused all nuclear activities within the Executive branch. The centers of power were clear, and they cooperated effectively. Then, about 15 years ago, when strong government direction was most needed, nuclear energy functions were totally reorganized. The JCAE was dissolved and its functions were assigned to a variety of committees and subcommittees. The AEC also was dissolved and its functions were assigned to a newly formed Nuclear Regulatory Commission (NRC) and to various parts of what is now the Department of Energy (DOE). In effect, the government's nuclear energy administration decapitated itself.

The need for a strong government role did not change with the reorganization, nor has it lessened because of a declining nuclear program. A strong government role is needed today even more than before, in order to meet a stronger challenge. The challenge is only partly that of managing an ongoing policy program; the other part requires reestablishing a virtually defunct industry. That will be no less difficult than the initial establishment of the industry.

The Advent of Standardization

Industry-wide plant standardization has never been a major goal of most US utilities. Most have valued their independence and have pursued separate designs according to individual company interests. While this type of individualism worked well for fossil-fuel and hydropower systems, the needs of nuclear systems have proved quite different, because they are much more complex. Five Nuclear Steam Supply System (NSSS) vendors existed in the USA at one time. Over a dozen architect-engineers and numerous construction contractors and subcontractors participated in building the nuclear industry in the USA. Each organization added its own way of doing things, and a variety of designs, construction techniques, safety provisions, and operating systems resulted. Reviews of all those individual systems, most of which were singular designs, overwhelmed the NRC. Design requirements escalated as the best aspects of each design became a standard for all other designs.

France, currently the country with the most successful nuclear program, has extensive standardization. Nuclear plants in France are built under a single owner, the national utility Electricite de France (EdF) and a single NSSS vendor, Framatome. EdF controls plant design, construction, and operation. Equipment suppliers and construction contractors enjoy repeated contracts, and so are able to apply and reapply their experience. Operator training also is standardized, and operators can move from one plant to another with little difficulty.

While the US nuclear industry has not established standardization policies, because no new projects are in process, a consensus is forming that standardization is desirable and inevitable. The single utility French model is impractical in the USA, but many of the French principles could be used. The number of approved designs could be limited to two, and the industry could be structured around that number.

Environmentalism As A Force

The most important single political and social force affecting energy production in the USA is that of environmentalism. The nuclear industry has received only a fraction of the credit it deserves as a positive force for environmental progress. In fact, the reverse seems to be true, for it has received a great deal of undeserved discredit. Nuclear power's greatest advantage comes from the waste disposal options provided by the fission process, and this asset has been turned into one of its its greatest political liabilities.

In the combustion of fossil fuel, matter is only changed in form. The weight of the waste, whatever the form, must equal the weight of all materials used in the combustion process, such as the combination of coal and air. Because a large coal plant may burn a million pounds of coal per hour and uses vast quantities of oxygen in the process, the total mass of waste greatly exceeds the mass of the coal. Roughly 15 percent remains in the form of ash while the remaining 85 percent is discharged into the atmosphere as gas, which creates smog, acid rain, the greenhouse effect, and other problems. In reality, burning fossil fuels only takes solids from the earth and puts most of them into the air as gases.

In the fission process, comparatively miniscule amounts

©NUEXCO 1987

of material are converted into enormous amounts of energy. Several thousand pounds of fissionable material are enough to fuel a large plant for a year and will produce a roughly equivalent amount of waste, not the millions of tons produced by, for example, a coal-fired plant. There are, of course, different forms of waste, such as irradiated materials and fission products, but they can be contained using well-developed and easily-applied technology.

The critically important difference between the two processes is that the volume of waste associated with the burning of fossil fuels makes containment and control impossible. It must be released to the environment either as a gas or solid. Mechanical and chemical aids, such as scrubbers, can lessen the degree of atmospheric pollution, but these are only partially effective. Volumes of fission products, on the other hand, are sufficiently small that, even though they are highly radioactive and difficult to handle, they can be kept virtually under man's permanent control. They need never be released into the environment.

The two types of available technology, nuclear and fossil-fuel, provide a fundamental environmental choice. The public must decide whether its interest is best served by releasing large volumes of waste into the atmosphere or by retaining and monitoring small volumes of waste on earth. The choice is obvious, but that obvious choice has not been made.

Prevailing public attitudes will be difficult to change. Nevertheless, facts can displace myths. Not all people interested in the environment are of a single mind. At one fringe are the highly-visible extremists, who have co-opted the "environmentalist" title in the name of a "return to nature", anti-progress, anti-technology philosophy. It is unlikely that much change in the attitude of that segment will be achieved, although it is not impossible and should not be ignored.

The more important group is also a much larger group. This group consists of citizens with environmental interests based on ethics related to cleanliness, aesthetics, conservation, and so forth. They possess an ingrained ethic much like the work ethic. A large part of this group consists of educated professionals who can readily understand the difference in consequences between the use of fission and fossil-fuels for power generation.

The two groups — the messianically-oriented one on the one hand, and the ethic-oriented one on the other — derive their views and visions from fundamentally different assumptions. They will consistently differ on national defense, welfare, and many other issues. But they all agree upon a need for a clean environment. It is this parallelism of views that makes the support or opposition of the "environmentalists" the most comprehensive single force in the USA today affecting the future of nuclear power. Industrial and population growth make it difficult to provide solutions that keep up with or anticipate the growth of problems. Public support for ever-increasing new government regulations has no limit in sight. The nuclear industry's challenge is to flow with that tide. Fortunately, I believe, the nuclear industry has the ability to accommodate that force.

Project Management, Systems Design, and Operation

The early turnkey nuclear power plant projects managed by General Electric and Westinghouse were completed in five years or less at a fraction of today's costs. With expansion, project management shifted to utilities and engineer-constructors and the industry's growth greatly increased the difficulties of building nuclear plants in a reasonable time and at a reasonable cost. Design changes, due in large part to increasing regulatory requirements, overwhelmed the system. Construction schedules lengthened and costs rose. Projects changed from fixed-price to cost-plus contracts. Public utility commissions applied the "prudent man" test with hindsight. Benefits from "prudent" management were often passed to consumers while costs from "imprudent" management were passed to shareholders. .

System design became more difficult as the pace of change increased. The NSSS design was provided by one of several US suppliers, and the balance-of-plant design was provided by one of a number of architect-engineers. As integration of all those affected by design changes became more difficult, it became apparent that a single-system design organization, such as that used by Kraftwerk Union (KWU) of West Germany, Asea-Atom of Sweden, and Toshiba of Japan, had important advantages.

The quality of the plant's operating staff makes major differences in operating results of all types. Utilities operating under similar circumstances and with similar plants have shown remarkably different results. Nuclear technology is "human intensive" and requires many highly trained specialists. A well-staffed organization is most readily attainable by multiple-plant operations. To be sure, size is

© NUEXCO 1987

no guarantor of success. But on the whole, the type of technological complexity found in the nuclear power industry is usually best served by balanced organizations large enough to support the full range of specialists.

Responding to New Conditions

Current conditions are quite different from when the concepts now in use were developed. Though some problems remain, a vast amount of light-water reactor experience is available. Other nations' approaches are available for comparison. Two major accidents, one American and one Russian, have occurred and have altered public perceptions about siting plants close to populated areas. Public concerns over nuclear safety require that those matters be dealt with realistically. Radioactive materials are becoming more difficult to ship and further transportation difficulties may be in store. The role nuclear power may play in nuclear weapons proliferation is of concern to some. The way the industry is organized is shifting and could change radically within the next 20 years. Better and more specialized nuclear management is required. One must look beyond these conditions for electrical generation investments over the next 50 years.

One conventional assumption is that an energy crisis which "turns out the lights" will force a resolution of the nuclear dilemma. In theory such a crisis will result in a consensus between government and the public, giving the government a clear mandate for more nuclear power. Under this strategy we need only wait for that shortage, which many expect to be inevitable, to have a resurgence of nuclear construction. When the crisis occurs, the technology that is already available can be taken off the shelves and put to use.

This is not realistic. When the need does develop we are likely to find that the existing solutions do not match the problem. The nuclear industry will again fail to understand the market. A crisis that significantly affects the public quickly becomes a political problem, but political pressures produce short-term trade-offs rather than attention to long-term solutions. An electrical shortage would probably result in rationing (probably disguised as "conservation"), rapid construction of gas turbine facilities, and other expediencies.

Nuclear power can only become a solution when we are able to plan for the long-term needs of the nation. Some people believe that even without a crisis, the nuclear industry will return to health because of its economic advantages and the obvious benefits of using uranium to supplement a limited fossil fuel supply. Nuclear power had a clear economic advantage for at least a decade, and continues to have an advantage in many areas. In spite of this advantage, the industry has declined. If nuclear power can command the strong support of the environmental movement, as it is so well suited to do on technical grounds, a new beginning is not only possible, but probable. The combined factors of favorable environmental impact, increased energy security, and advantageous economics, in that order of priority, should produce results. But what sort of industry may be suitable for conditions as they now are and as they are likely to be? What can we envision?

Generating Companies and Nuclear Parks

The trend towards deregulation, the need for remote siting, the difficulty of obtaining new sites of any type, and the need to make sites self-contained all indicate that nuclear parks may be a desirable solution to nuclear siting problems within the next 20 years. These parks would require a tremendous investment, well into the tens of billions of dollars, but they could concentrate on power production under specialized managements, specifically trained for nuclear operations.

For purposes of illustration, one can envision a multiple-plant nuclear park, with its ownership formed exclusively for producing and selling bulk power to customers located throughout a entire region, such as the western USA. Various forms of ownership might be used, such as a publicly-owned company, or a joint venture of one or more utilities. Regulation might be applied more at the federal level than is currently the case. The company would sell its power in competition with other power-generation entities, including other parks, cogeneration operators, and small and large suppliers of other types.

A high degree of site integration with the back end of the fuel cycle is essential. On-site facilities would provide a number of fuel-cycle operations, such as reprocessing spent fuel, recycling remaining fissionable products as fuel, isotope separation, and packaging and storage of waste. The purpose of these facilities would be to make shipment of radioactive materials from the site unnecessary for many years. As the nuclear park would be large, isolated, self-sufficient and integrated, it might resemble in

©NUEXCO 1987

many respects the early Hanford and Savannah River installations. Its location would create minimal community disturbances, and, as in France and Japan, tax and employment benefits could be used to advantage.

Such nuclear power stations would have safety features that go beyond those used today, including "inherently safe" designs (that is, a conditional self-shutdown of power and the avoidance of possible core meltdown). Reactor designs would be of a standardized type, proven by large-scale prototype testing. Large operations such as this would have to develop more in-house capability in design integration, project management, and training. Deregulation might permit the acquisition of industrial support companies that would not now be allowed

New Requirements for Government

The government needs improved nuclear licensing procedures. Past practices have strangled the industry without increases in nuclear safety. Improvements are needed not only for continuing operations but also for new projects, but improved licensing alone will not motivate new construction. Assurances that the government may provide at one point in time can be taken away at a future point in time. The owners and managers of nuclear utilities have to take the long view, and that includes evaluating the risk of potentially adverse, retroactive government decisions.

The nuclear industry needs the following from the government:

1. Research and development funding is essential to develop new technologies, including increased emphasis on the back end of the fuel cycle.
2. The government must fund a portion of the cost of a prototype program, where the cost exceeds the value to be recovered from electricity production. Extra costs will result from the prototypes' sub-optimal size, and from component and plant testing.
3. The government must be made financially accountable for the potentially adverse effects of government decisions. For example, if the government imposes costly regulatory requirements after a project's approval, government funds should compensate for the consequences. Although from the government's point of view there are difficulties associated with such guarantees, the difficulties associated with costs to the shareholders are greater.
4. Binding agreements must be signed with public utility commissions and other regulatory bodies at the start of a project, to avoid after-the-fact "prudency tests." Prudency must be considered at the time decisions and forecasts are made, and must apply to public utility commissions as well as to owners.

Congress will not easily provide government assurances for new nuclear prototype development. Public opinion must assure that such actions will be viewed as politically positive ones rather than negative. Considerable time will be required for this kind of public pressure to build, and it is most likely to come from environmental concerns.

Changing NSSS Supplier and Architect-Engineer Roles

Standardization, centralized project control, integration of systems design, and expanded utility capability will force changes in the roles of NSSS vendors, architect-engineers, and service companies. Especially if new, larger generating companies are formed the utilities will tend to expand their scope at the expense of others. Standardization also will necessarily reduce the number of participants. Limiting reactor designs to two standardized types, for example, would suggest no more than two NSSS vendors (if they remain as suppliers). Architect-engineers might be similarly limited.

Because of new conditions, it is not clear what form a supplier industry might take. One can envision the possibility of one or two companies similar to Asea-Atom of Sweden and Kraftwerk Union of the Federal Republic of Germany, which provide integrated design, construction, installation, and start-up capabilities. An integrated company in the USA could be formed around a major construction firm, such as Bechtel, or a major generating company might establish a supply company which not only would serve its own needs, but those of others as well. What does seem likely, in any event, is a less fragmented industry.

A Transition Solution: A Prototype Demonstration Program

US nuclear designs were largely conceived in the 1960s. A market mismatch obviously exists, for those designs are not accepted in the USA and a newly-active nuclear market may not emerge for 10, 20, or even 30 years. Even so, there is a need to maintain some continuity in US nuclear energy capability, to keep the USA at or near the forefront of technology and to have proven, tested, acceptable new

©NUEXCO 1987

designs available when they are once again needed. How can the industry survive this transition period? The best mechanism appears to be a prototype program. No other alternative even appears possible; it seems most unwise to assume that utilities will soon again be building nuclear plants, and even if they do, a prototype program still would be advantageous because normal construction may not provide the needed advancements.

A successful prototype program would have several objectives:

1. To design, build, and test models which would meet projected social and technical safety requirements;
2. To develop self-sufficient systems appropriate to the "nuclear park" concept;
3. To update our vast experience in light-water reactor technology and to translate that experience into licenseable, standardized designs available for use within ten years;
4. To construct light-water reactor prototypes, and possibly other types, that would be suitable for long-term commercial electrical generation following testing.
5. To evaluate advanced technologies.

Composition of the Prototype Program

I suggest four reactor prototypes and one fuel-cycle development facility as an appropriate program. The four reactors would consist of two light-water reactors, one Integral Fast Reactor, and one High-Temperature Gas Reactor.

The proposed light-water reactors would be in the 300 to 600-MWe range. They would be designed with inherent safety and whatever additional safety features are needed to ensure public acceptance. They would be compatible with fuel cycle developments. All designs would be expandable for larger sizes.

The Integral Fast Reactor prototype would be smaller, possibly 50 to 150 MWe. That reactor is said to possess simplicity, inherent safety, features which make diversion of fissionable material difficult, and the capacity to use reprocessed and recycled fuel and waste as part of the total system. It appears to have many attractive features, and if the claims prove valid, a prototype to produce a licensable design would be the next logical step.

Government and industry have supported high-temperature gas reactor technology programs costing approximately $30 million per year for some time. Many in the nuclear industry believe that this type of reactor has significant potential safety and economic advantages. The prototype program would utilize the research and development results and evaluate the advantages and disadvantages. A size similar to that for the Integral Fast Reactor, or 50 to 150 MWe, would be logical. If results merit continued work, the next step would be a larger prototype and a program similar to those proposed for light-water reactors. In addition, the fuel cycle project would develop miniaturized reprocessing, recycling, isotope separation, and waste handling processes useable with all types of reactors.

Financing

The cost of the five projects probably would be in the range of $4 to $6 billion, or roughly equivalent in magnitude to DOE's Superconducting Supercollider project. Overall, its value for purposes of electricity generation may be $2 to $3 billion. This suggests that financing could be accomplished partly by operators interested in electrical production, partly by utilities benefiting from the later availability of advanced nuclear power designs, and partly by the government for its different reasons. The government and utility portion may amount to 2 or 3 billion over about 15 years, so that annual costs would be about 150 to 200 million per year, not a large sum compared to present expenditures.

Use of The Idaho National Engineering Laboratory Site

A test station now exists which would adequately, and perhaps ideally, suit the prototype program: the Idaho National Engineering Laboratory. The Laboratory has a long history of testing naval reactors and training personnel, and it has experimentally tested small light-water reactors and fast-breeder reactors, including the Integral Fast Reactor. The operation has the support of the surrounding community and every level of state government. A trained and experienced work force of 10,000 is performing work similar to that which would be required for prototypes, which could be tested side by side and under common circumstances. Support facilities also are available for these types of activities. Electricity could be exported to the Northwest, West, and Southwest. Using such a site might also eliminate the lengthy investigation and negotiation that often accompanies major nuclear projects. Comparable sites might also be found at Hanford and Savannah River, although neither appear to offer assets comparable to those of Idaho.

©NUEXCO 1987

Some Near-Term Actions

A number of near-term actions should be taken to support a prototype program and to turn the declining US position around.

1. We must develop a clear, specific picture of nuclear plant ordering requirements, as we anticipate them to exist around the year 2000. The result would be the equivalent of a product planning specification, and would define characteristics for prototypes and identify research and development needs.

2. We must define the prototype program in detail. We must formulate specific roles for government, utilities, and others and develop a practical funding plan.

3. We should prepare conceptual designs for a nuclear park, and use them to aid development of specifications and for public relations. The public tends to think that nuclear power has reached the limits of its technology, that what has been done is all that can be done. The nuclear industry needs to show that the limits of technology have not been reached and that new and exciting possibilities lie ahead.

4. We must define the government's role if it is to allow our industry to move ahead. Specifically, under what conditions would a progressive utility or other nuclear company be able to move forward.

5. We must formulate a public relations program whose priorities emphasize nuclear power's intrinsic environmental advantages and aesthetic possibilities (including the possibility of underground construction). Priorities in public relations should be in this order: (a) environmental advantages, (b) futuristic conceptual designs based on possible advancements in technology, (c) use of readily available fuel supplies from friendly nations for fuel supply security, and (d) economic advantages.

Summary and Conclusion

One may argue that nuclear power is not dead in the USA, as the more than 100 plants in operation demonstrate. However, operation of existing plants does not mean a strong future US role in nuclear energy affairs. Leadership requires a nuclear program that takes the initiative, so it requires the building of new facilities. Only active projects can result in coherent, realistic programs. Concepts of design, siting and operation used in the past no longer fully apply; they need updating. Active programs must shape the future without expecting to return to the past. There is little, if any, likelihood that utilities will order nuclear plants as part of their normal generating programs until new and different government actions are evident.

The gap in new nuclear construction may last for 10 to 20 years. This gap needs to be filled. Those responsible for national electrical energy supply leadership must initiate a program to fill that gap. A prototype program is an affordable answer. Government assurances will be forthcoming only when and if public attitudes encourage action. Our basic need, therefore, is to focus public attention on matters of the greatest short-term public interest, and particularly those affecting the public's perceptions of environmental, safety, and waste matters. If we apply ourselves to these goals, nuclear power can, and very likely will, experience a resurgence of confidence and activity in the USA.

© NUEXCO 1987

PRODUCTIVITY IN US URANIUM MINES

Introduction

In 1973, US uranium mine employees produced an average of 31 pounds of uranium concentrates per manshift. In 1979, that average had fallen to 10 pounds, but by 1983 it had risen to 27 pounds. These variations have primarily been caused by market forces.

During the period 1967-1982, the Grand Junction, Colorado office of the US Atomic Energy Commission (AEC) and its successor groups annually published data on a variety of aspects of the US uranium industry. These data included numerous details of mine production and mine employment from which mine productivity may be calculated for that period. After 1982, the US Energy Information Administration assumed responsibilities for tracking uranium industry data, and modified the format from that used previously. Under the new format, some types of data were no longer published, in particular, distribution of mining employment by mine type and work category. Thus, it is not possible to extend a complete set of productivity evaluations through the period 1983-1985.

Definitions and Background

In any industry, productivity is a measure of labor efficiency, and may be defined as the ratio of output to input. In mining, productivity generally is measured as the ratio of output (in tons) to input of labor (in manshifts). This measure is particularly applicable to coal mining where the mine output is marketed more or less directly, and does not require further processing. Many other types of mining, including most metal mining, produce an ore which contains only a small percentage of the finished commodity. In those cases, productivity can be equated to actual metal output through the tonnage and grade of ore produced. In the case of uranium, the output/metal content relationship is given by the following formula:

$$\underset{\text{(pounds } U_3O_8\text{)}}{\text{Output}} = \text{Tons of Ore} \times \underset{(\%U_3O_8)}{\text{Ore Grade}} \times 20$$

Output might also be measured in terms of revenue generated by applying a price to production. In addition to its effect on revenue, price also can have a significant impact on the quantity of reserves available for exploitation, through the mechanism of "cut-off grade." In metal mining, most deposits exhibit a distribution of ore grades, not all of which are economically exploitable. Ideally, "cut-off grade" defines the economic break-even point of production. As prices rise, the cut-off grade is lowered to include material previously classified as sub-economic. Because the distribution of ore grade is lognormal (most mines have greater tonnages of low-grade ore than of high-grade ore) for most trace-metal deposits, small changes in cut-off grade can cause large changes in reserves and, as a consequence, mine life.

The cut-off grade also has a regulating effect on mine profitability. In times of high prices, a mine operator can mine lower-grade ores thereby extending reserves, but production costs, per unit of metal produced, will also be high. The reverse is true during times of low prices.

Technology, both positive and negative, also affects productivity. In this case, positive technology means improvements in equipment and techniques that, in turn, produce greater production efficiency. Examples of positive technology include the expanded use of rubber-tired diesel equipment, high-speed hydraulic-powered drills and raise boring, and the introduction of more efficient ground support systems such as split-set rock bolts. "Negative" technology (in the sense of not contributing to productivity) can include constraints imposed on personnel, equipment and methodologies by management or regulatory bodies for the purpose of improving health, safety and environment. The uranium mining industry has been hit hard in recent years by such constraints. Combined with low prices, the result has been an industry of greatly reduced size. This reduction also has its good side, however, in that new efficiencies are sought out and introduced and old inefficiencies (including people and companies) are phased out.

Price Trends

Price is the constant that affects any analysis of mining cost or productivity. In the short term, price controls marginal cost. In the long term, economists believe that the opposite occurs. The period under review is relatively short in economic terms, and most of the effects shown will relate directly to price.

Spot market uranium prices have shown substantial change during the period 1967 to 1985 from a low of less that $6.00 per pound U_3O_8 in 1972 to a high of more that $43 in 1978, as indicated by the Nuexco Exchange Value. Since any price or cost analysis through time is complicated by the effects of inflation, it is sometimes more useful to

© NUEXCO 1987

show prices in constant dollars. In Figure 1, the Nuexco Exchange Value is shown both in constant 1986 US dollars and in historical dollars. Using constant dollars, prices in effect during 1967 to 1974 are similar to the prices from 1982 to 1985 and provide an interesting background for comparison. Constant dollar prices were developed using the Producer Price Index for Industrial Commodities. Most of the graphs presented in this article use a background shading of the constant-dollar price curve to illustrate the effects of changing prices.

Production Trends

US uranium mine production has dropped substantially since 1980, when 40 million pounds of U_3O_8 were produced from 17 million tons of ore. In 1985, US mine production was 6.3 million pounds U_3O_8, from 1.5 million tons of ore. Most of this reduction can be attributed to decreasing prices and to a lack of higher-grade, low-cost resources. Figure 2 shows US mine production of uranium concentrates for the period 1967 to 1985. Historically, most US uranium production has come from underground mines of the Colorado Plateau and the Grants Mineral District. Wyoming has had the major share of open-pit production in recent years, while Texas and Washington have produced smaller amounts.

Underground mining seemed to react slightly more quickly to the price rise of the mid-1970s than did open-pit mining. Overall, however, production response has tended to lag behind price changes by two to three years. By factoring constant dollar prices into the uranium production situation (Figure 3), the full impact of price/production decreases can be seen. It is not surprising from this graph that the US uranium industry has been declared non-viable. The value of the product produced in 1985 was only about 4 percent of the 1978 value, a most discouraging change for the uranium mining industry.

Average mine production ore grades have responded fairly rapidly to changes in price (Figure 4). Recently, the underground mine production ore grade has shown almost an inverse relationship to price, and is the result of the cut-off grade mechanism and the flexibility of production grade in underground mining. The longer-term decline in ore grade from open-pit mines is primarily the result of the time-lag between mine development (stripping of overburden and waste) and the production of ore from the mine. Significant expenditures for open-pit mine development were made during the period of higher prices. By the time much of the ore was uncovered and available for mining, the period of peak prices had passed, but production had been set, in part, according to assumptions of future prices. Of course, much of this production was sold forward under long-term contracts and prices received under these contracts exceeded the spot price. Thus, low-grade ores committed under such contracts could be open-pit mined at a profit.

Employment Trends

Between 1967 and 1985, uranium mine employment peaked at 13,000 in 1979 and then declined to a low of 1,200 in 1985, as shown in Figure 5. This overall employment curve is composed of three primary elements—open-pit employment, underground employment and mine staff employment. As Figure 5 shows, underground employment responded somewhat more quickly to the 1973-1976 price increase than did employment in open-pit mines. This reaction can probably be attributed to less lead-time for the smaller underground mining equipment required for expansion of production.

The overall shape of the employment curve is very similar to that of the price curve, but tends to lag behind price. This may be due to the fact that the majority of production was sold under medium to long-term contracts and, thus, was somewhat price insensitive in the near term downtrend.

Mining operations require a significant number of hourly-paid support personnel for logistics and maintenance. Figure 6 shows the ratio of support personnel to miners for open-pit and underground mines. While open-pit mines show no definite trend, it is clear that support labor requirements in underground mining have increased significantly since 1967. Much of this increase probably can be attributed to an increasing emphasis on health and safety.

Traditionally, a mine staff might have consisted of one or two engineer/surveyors, perhaps a geologist, a purchasing agent, a secretary, and a mine manager, along with a few support staff. Increasing paperwork requirements associated with regulatory permits, health and safety, industrial relations and financial/shareholder responsibilities have greatly increased the ratio of mine staff to mine production employees (Figure 7). This category of employment totaled almost 3,700 in 1979, three times as many staff workers alone as the entire industry workforce in 1985.

Productivity Trends

A recent Swedish study on productivity in underground

©NUEXCO 1987

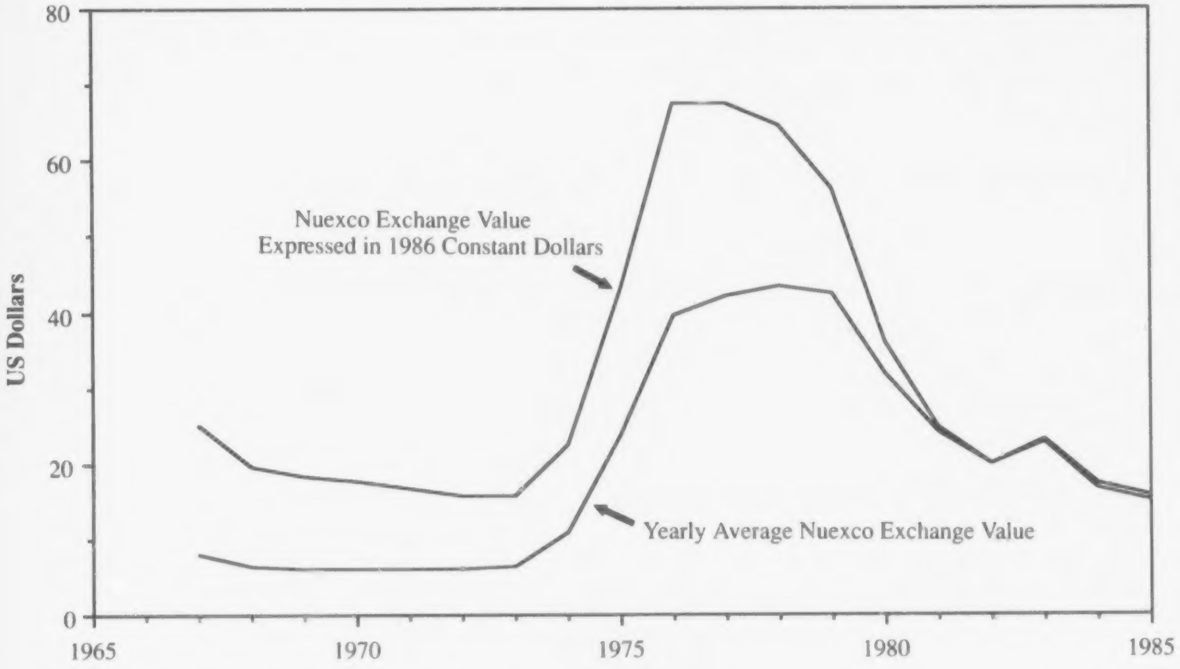


Figure 1
URANIUM PRICES

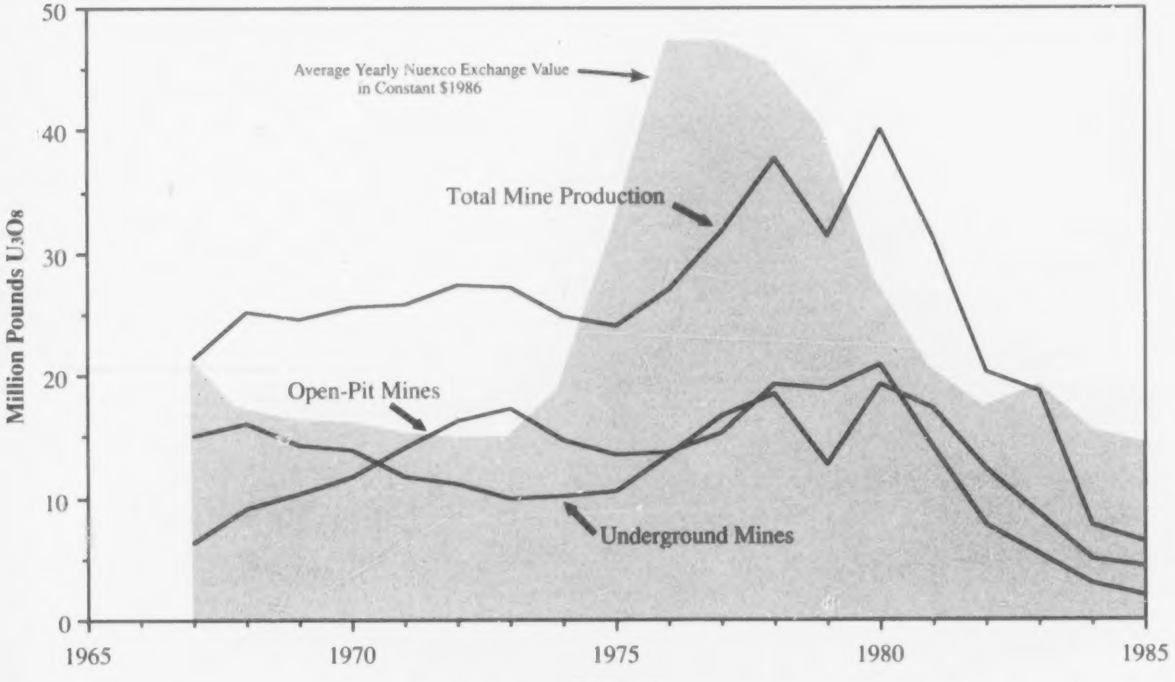


Figure 2
HISTORICAL MINE PRODUCTION

© NUEXCO 1987

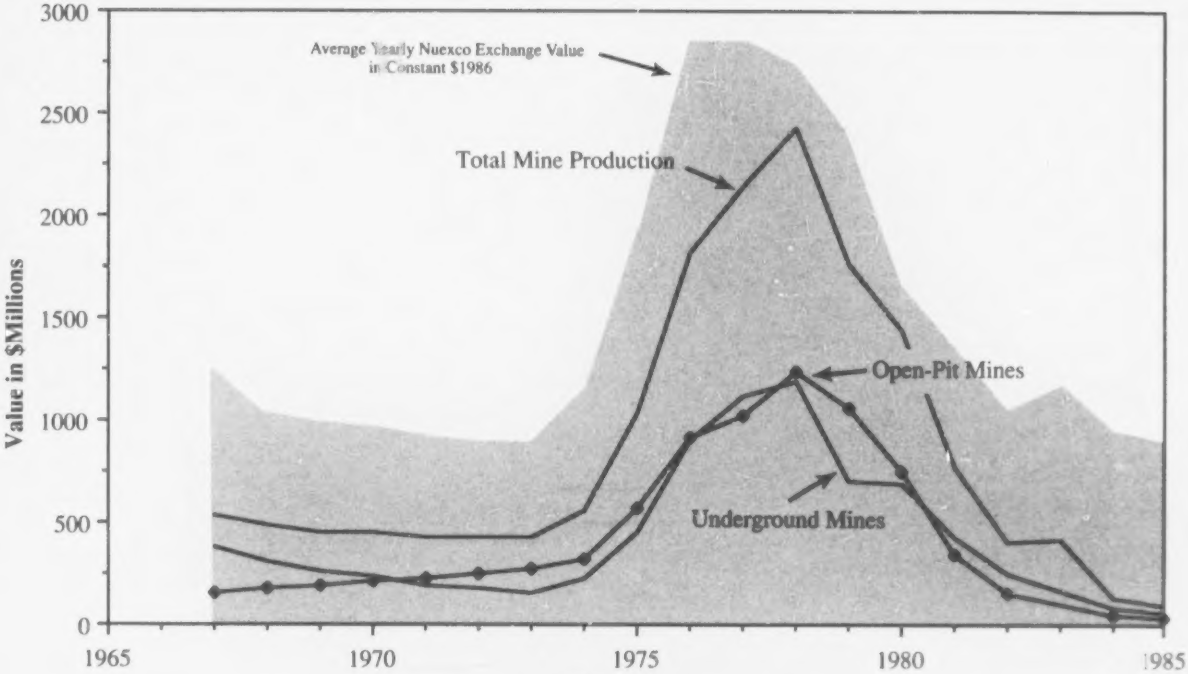


Figure 3
VALUE OF US URANIUM MINE PRODUCTION
(Constant 1986 Dollars)

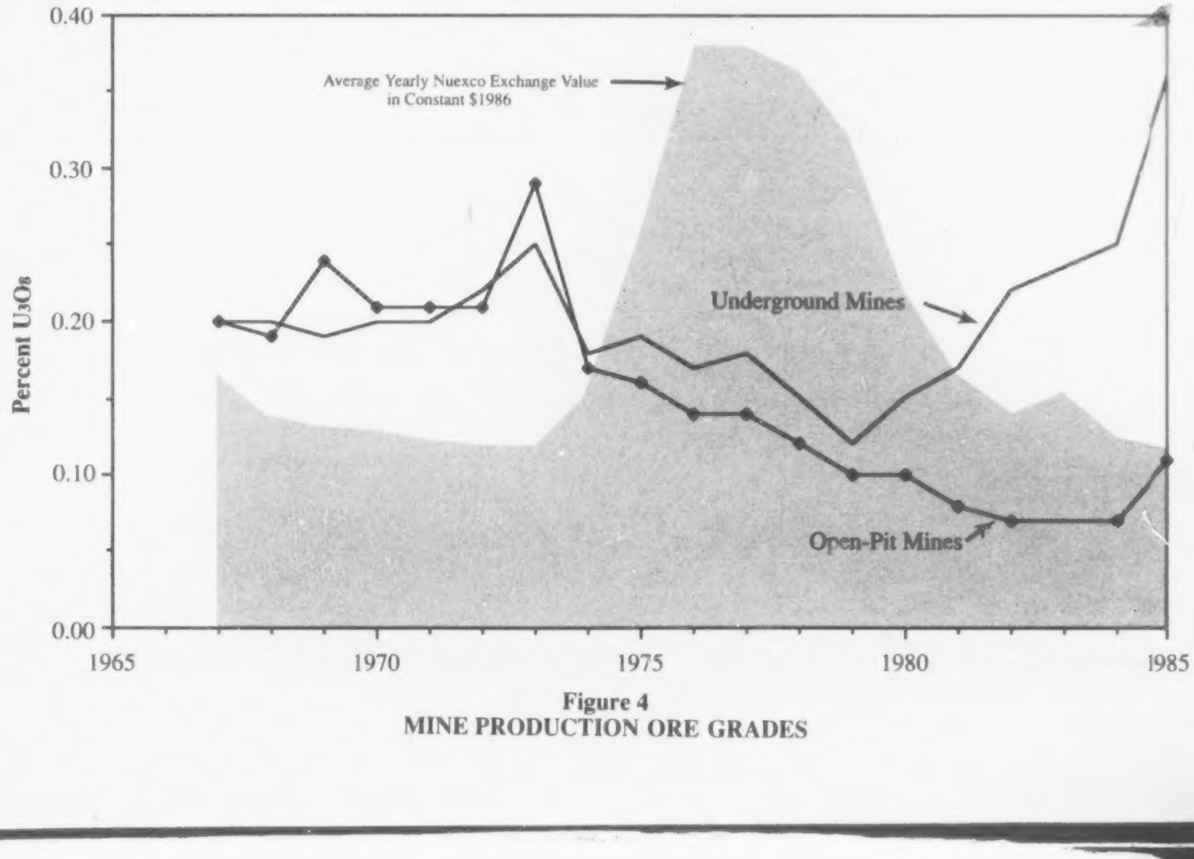


Figure 4
MINE PRODUCTION ORE GRADES

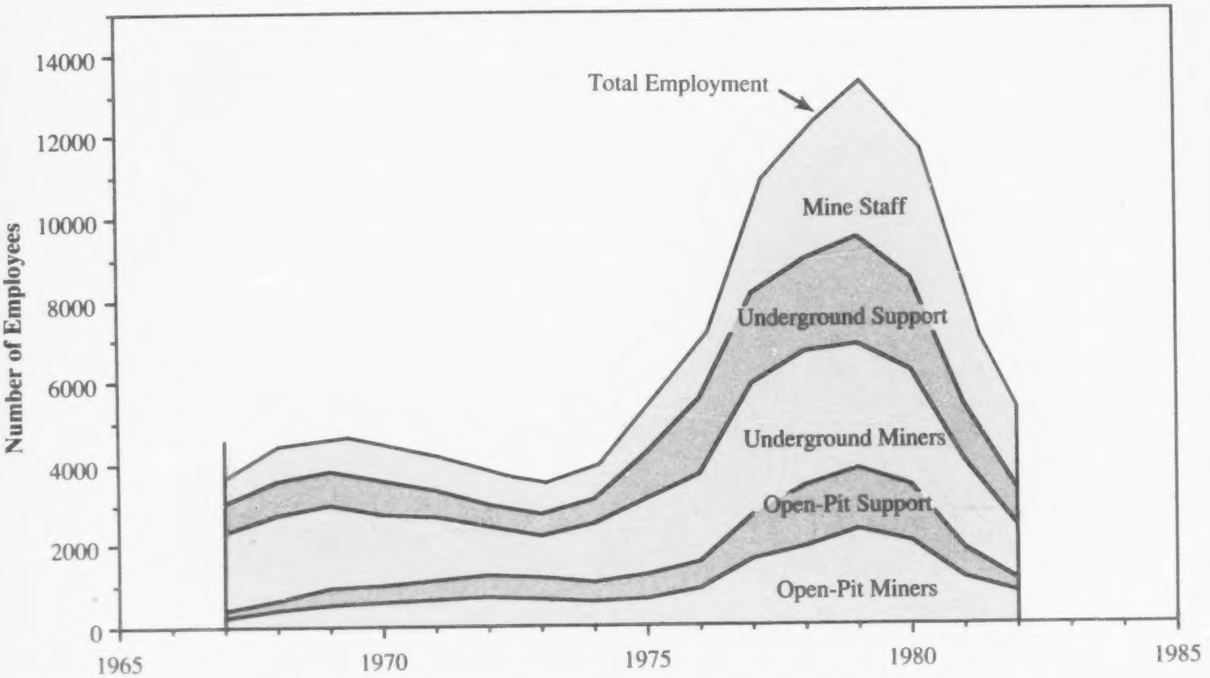


Figure 5
MINE EMPLOYMENT BY CLASSIFICATION

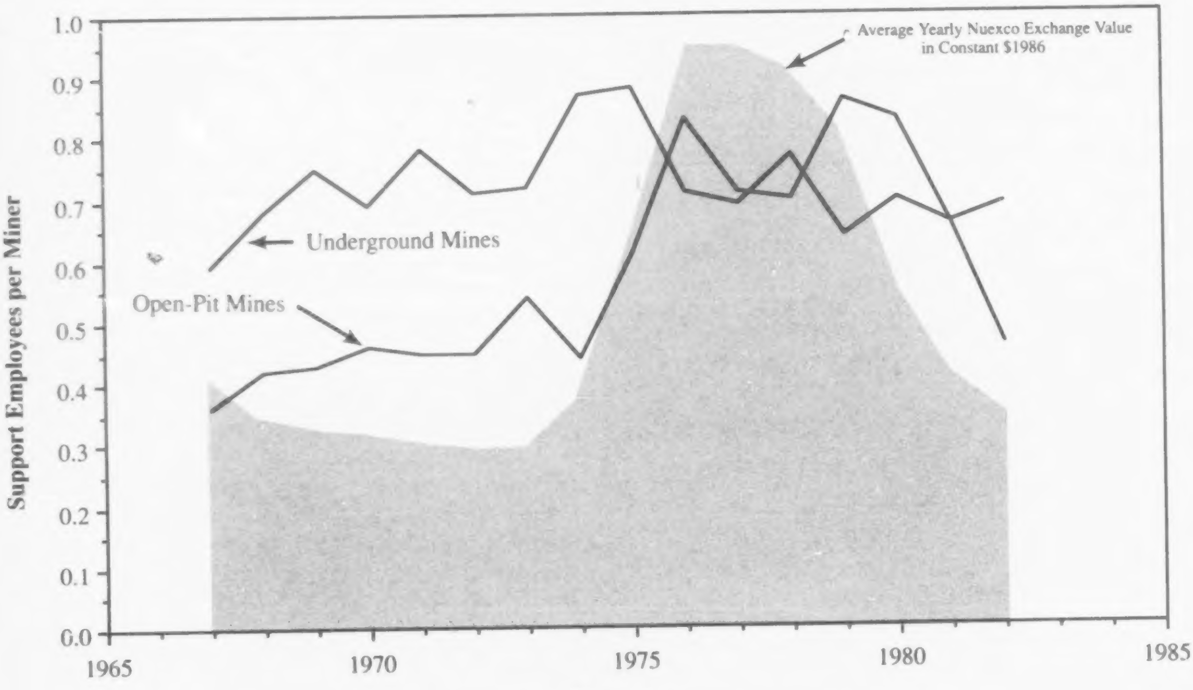


Figure 6
RATIO OF SUPPORT AND SERVICE PERSONNEL
TO MINE OPERATING PERSONNEL

RAW MATERIALS

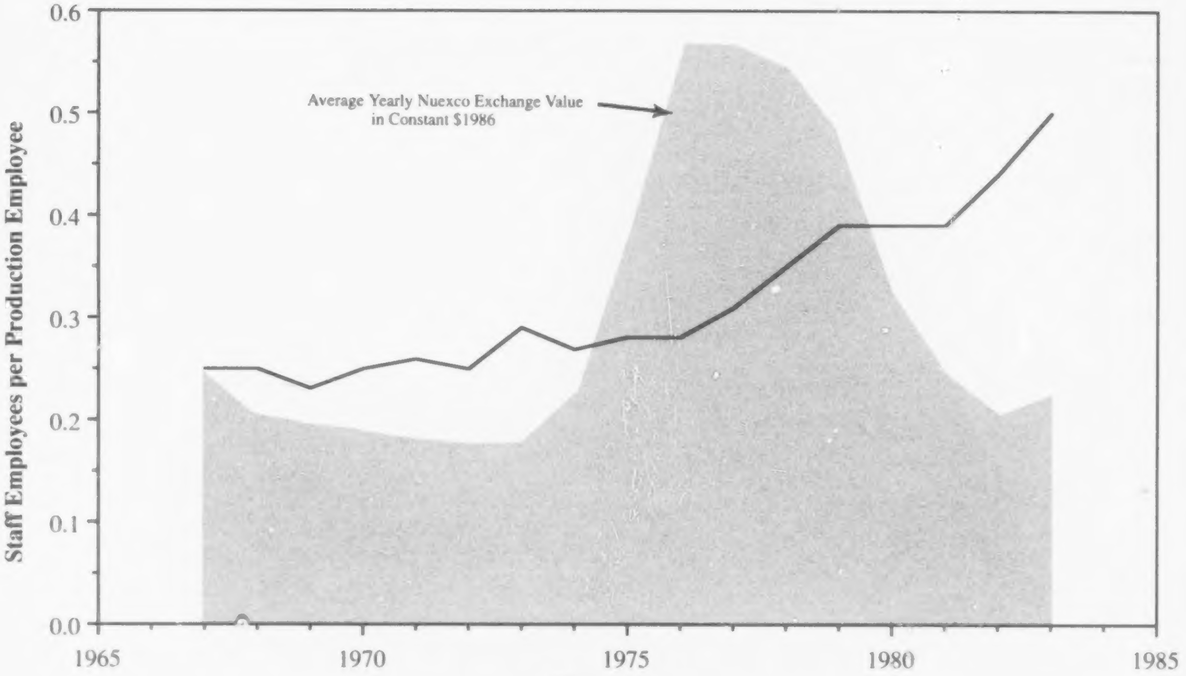


Figure 7
RATIO OF MINE STAFF EMPLOYEES TO MINE PRODUCTION EMPLOYEES

mining listed the following US metal mining productivities based on US Department of Labor and Bureau of Mines data for 1982 (Table 1).

Table 1
UNDERGROUND MINING PRODUCTIVITY

Type of Ore	Productivity (Short Tons of Rock/Man-hour)
Copper	3.0
Gold	0.7
Iron	16.8
Lead and Zinc	1.7
Tungsten	1.3
Uranium	0.8

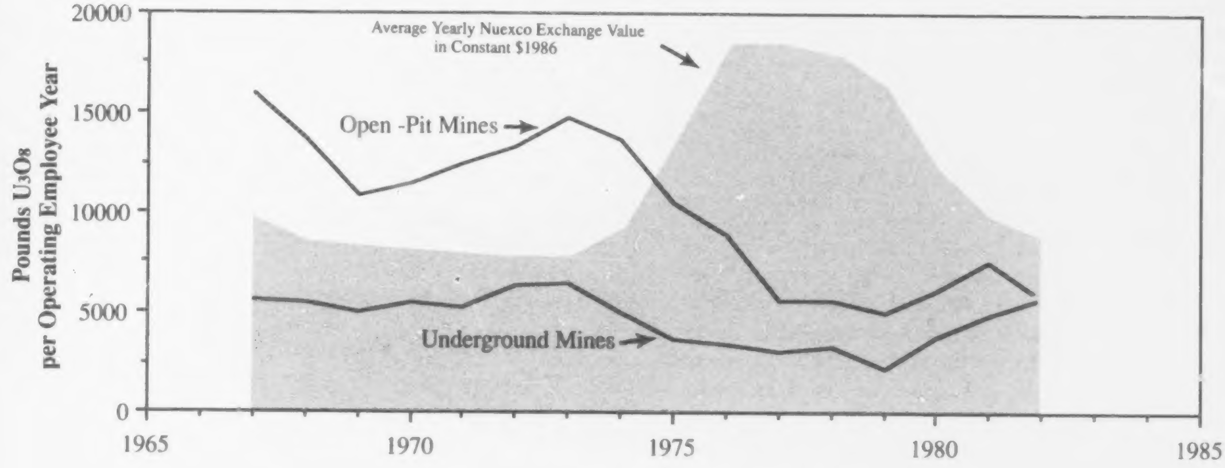
The principal reason for the differences shown is the degree of selectivity required in mining a "typical" deposit for each type of ore. Iron is commonly mined from massive deposits where large, efficient equipment can be utilized. Gold is commonly mined very selectively with small-scale equipment. Most uranium is produced on a scale and methodology similar to that used for lead and zinc, but two primary differences are apparent:

1. Underground uranium mines require substantial efforts for radon abatement through control of ventilation and drainage; and
2. Most underground uranium mines occur in relatively soft rocks which are not-self-supporting and which, when wet, degenerate to mud.

Figure 8 shows two views of productivity in US uranium mines. This figure provides support for the following observations.

Mining productivity should remain relatively constant for "type" deposits and technologies. Figure 8, however, shows a significant drop in ore per manshift productivity during the peak price period of 1975 to 1979. This drop could mean "slacking off" during a period of plenty, as opposed to "belt tightening" during bad times. For open-pit mining, the drop-off may better reflect increased stripping ratios, while for underground mining, it may reflect increased development.

© NUEXCO 1987



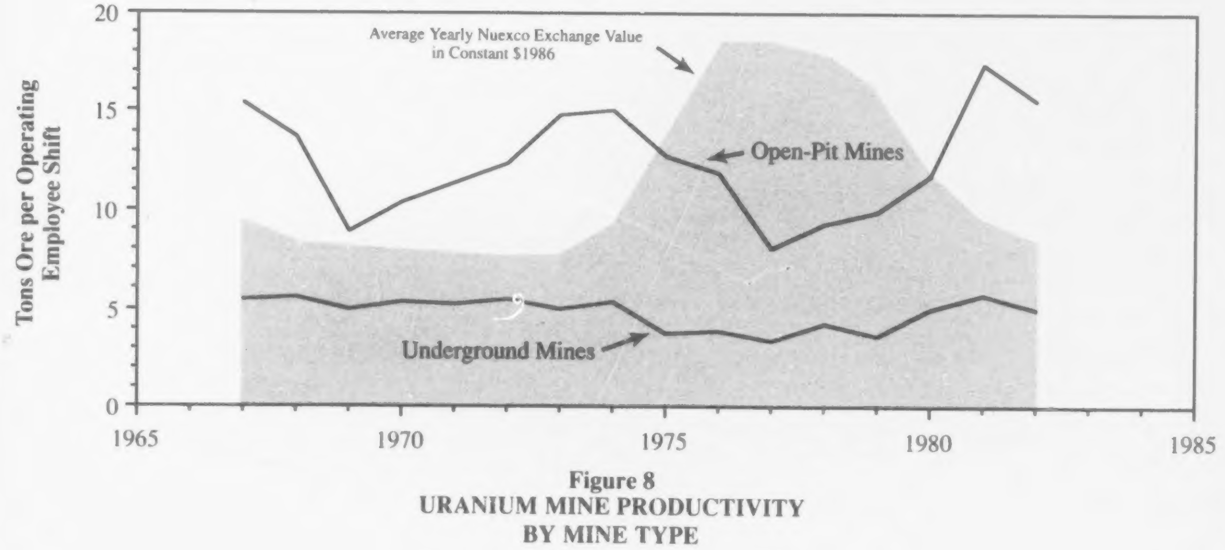


Figure 8
URANIUM MINE PRODUCTIVITY
BY MINE TYPE

© NUEXCO 1987

Comparing open-pit and underground productivities on a pounds U_3O_8 basis, during most of the period, open-pit miners generated far more pounds U_3O_8 per manshift than did underground miners. More recently, that gap has narrowed considerably. One might speculate that this difference is due to the increased mechanization at open-pit mines and is offset to some degree by higher capital-cost requirements. This measure of productivity mirrors price changes almost directly, and shows the cut-off grade mechanism at work.

Conclusions

Since most of the major changes in production, employment and productivity are coincident to major changes in price, there can be little doubt that the changes are directly related. Much of this relationship can be attributed to the cut-off grade mechanism which provides a certain flexibility to most mining operations. Mining costs are related to tons of ore and waste handled, and mining revenues (at a given metal price) are related to the metal content of the ores. The cut-off grade mechanism allows a balancing of the cost/revenue equation, which dampens the influence of price changes. This mechanism also allows for increasing utilization of lower-grade resources in times of higher prices, and assures an almost unlimited supply (albeit at higher costs) of those resources. Some of these relationships are summarized in Table 2, which compares various characteristics of underground mining for the years 1973 and 1979.

Thus, major changes in productivity and price nearly offset each other in terms of the value produced per labor dollar. In terms of increased reserves, however, one may speculate that a 50-percent decrease in economically exploitable ore grade might result in a four-fold increase in economically exploitable reserves.

Uranium mine employment appears directly related to price and should enjoy some resurgence as a result of the recent court decision in favor of the US uranium producers. Much of this resurgence is likely to be several years into the future, largely due to the lead times required for expansion of production, but an eventual increase in uranium mine employment numbered in the thousands is a reasonable expectation. If past trends continue, an expansion of uranium production will require an increasing number of mine staff employees, both for technical and administrative support. Changes in future uranium prices can therefore be expected to fuel continuing change in uranium production, employment and productivity.

Table 2
UNDERGROUND MINING PRODUCTIVITY ANALYSIS

Item	1973	1979	Percent Change
Tonnage Productivity (Tons Ore per Manshift)	5.2	3.8	- 27
Average Ore Grade (% U_3O_8)	0.25	0.12	- 52
Uranium Productivity (Pounds U_3O_8 per Manshift)	26.0	9.1	- 65
Nuexco Exchange Value (1986 $/lb. U_3O_8)	15.89	56.18	+254
Dollar Productivity (1986 $ per Manshift)	413.14	511.24	+24
Labor Cost (1986 $ per Manshift)	95.99	97.87	+2
Value Produced per Labor Dollar (1986$)	4.30	5.22	+21

© NUEXCO 1987

THE URANIUM MARKET: IMPLICATIONS FOR SUPPLIERS

This article is an edited version of the speech given by Nuexco's R. Gene Clark, at the Uranium Institute's Twelfth Annual Symposium in London, England, September 4, 1987.

Introduction

It should be apparent that the buyers' market of the past several years has placed a great deal of strain on the world's uranium supply industry. Certainly some producers have enjoyed the benefits of older contracts, signed in the heyday of the sellers' market of the 1970s. However, not many of these typically fixed-quantity, escalated-price contracts will extend far into the future, and the world's uranium producers must recognize today's realities and tomorrow's uncertainties.

In the absence of effective restrictions on uranium imports into the USA, the marketplace will continue to be a buyers' market for at least a few years; but some of the factors causing this situation will ease as more nuclear power plants come into operation. To survive over the next several years, a producer will need not only favourable production costs but also an intelligent approach to the marketing of his product.

Today's Market

Several of the factors that turned the market from being a sellers' to a buyers' market were not a pleasant surprise to most nuclear fuel managers. The slowdown in nuclear construction, enormous cutback in planned nuclear programs, and the worse-than-expected operating performance of many nuclear plants have been important factors in the market's turnaround. To compound the problem both for nuclear fuel managers and uranium suppliers, one result of these under-realized expectations is still with us, in the form of large inventories of uranium on a worldwide basis. Only in the past two years have worldwide inventories started to decline toward more reasonable levels. Furthermore, in contrast to several years ago, inventory drawdown is almost exclusively by consumption rather than by sales on the open market. Although this is a welcome trend for the uranium and nuclear power industries, it will take at least five more years for these excess inventories to approach a normal level.

Producers can now rely on a solid base of operating nuclear stations, with more plants in advanced stages of construction. This means that the market demand for uranium will become increasingly based on real consumption rather than on expectations of future generating units' requirements. Uranium requirements should become much more predictable than in the past.

The majority of the world's economically inefficient production capacity has now been eliminated from serious consideration. Other than special situations in which certain producers still hold favourable long-term contracts, what remains of these high-cost projects, especially in the USA, is largely lingering production in lieu of reclamation. In the USA, there are some marginal mines and mills being held in partial standby status, partially in anticipation of an effective embargo on uranium imports. However, their owners seem to be primarily interested in financial assistance for mill decommissioning and mill-tailings cleanup.

Nuclear fuel managers have become increasingly more sophisticated in their approaches to managing and procuring uranium and nuclear fuel cycle services. Not too many years ago, industry consultants were much in demand by utilities to help plan utilities' fuel cycle activities, including the negotiation of contracts. While consultants are still providing these services, the level and scope of their involvement is much less than before. Utility fuel managers now generally use their own analytical tools to aid in their decision-making.

A fairly new development in the market is the increased importance of intermediaries — that is, entities that are neither producers nor consumers of uranium and fuel cycle services, but who may act as principals in the market. This development should not be confused with the much earlier phenomenon of reactor vendors or fabricators offering uranium, usually as part of a "package deal," to enhance their prospects in other areas. In past years, intermediaries were involved primarily in risk-free "back-to-back" deals, designed to mask identities and prices. However, their recent involvement has become more aggressive — taking commitments and attendant risks due to mismatches in delivery time, origin of material, delivery location, and form of uranium — in order to make the market function effectively.

In contrast to these changes in the marketplace, some things have not changed. Governments continue to regulate uranium trade, above and beyond their direct involvement as producers and consumers of uranium and nuclear fuel cycle services. Some governments still regulate export prices, transportation of exported material (because of nuclear nonproliferation concerns), and foreign investment in uranium production programs.

©NUEXCO 1987

ANALYSIS AND COMMENTARY

The Market Outlook

Two central questions in the minds of current and potential uranium producers must be:

1. Who are the potential buyers?
2. What kind of market pricing can we expect?

We can answer the first question by considering some interesting but generally well-known market factors — shown in Figure 9. By geographical groups, the USA has the greatest unfilled requirements well into the future, followed by Europe and the Far East. (An unfilled requirement is the amount of uranium a company needs, over and above its inventory level and purchase contracts, to meet projected enrichment feed deliveries plus maintain a desired level of inventory.) Although Europe and the Far East have similar levels of unfilled requirements, the Far East has a higher fraction of its total requirements uncovered by commitments. These groupings have important implications for the future marketplace. Buyers in the USA generally feel that one year's level of forward coverage in inventory is desired and have tended to procure uranium with the shortest lead-time before needs. Utilities in the Far East generally have been the most concerned with security of supply and tend to have the highest level of desired forward coverage in inventory.

Perhaps even more important, potentially restrictive trade conditions have made the USA the focus of the greatest uncertainty. Thus, the country with the largest fraction of future unfilled requirements is also the most uncertain as far as trade considerations are concerned.

Future market prices are, of course, subject to much greater uncertainty than are unfilled requirements. Figure 10 represents Nuexco's estimate of the distribution of world uranium production costs through the year 2000. These costs are for the lowest forward-cost properties required to balance supply and demand for the period. It is highly unlikely that the bulk of this required production will come into the market at current prices.

Many factors could affect the outlook for future prices. Perhaps the most important factor in the intermediate term is the prospect of a prolonged restriction on the use or enrichment of imported uranium in the USA, especially in view of its large fraction of the world's unfilled requirements. Another potentially influential factor will be the political situation both within South Africa and between South Africa and other countries. In the long term, there is

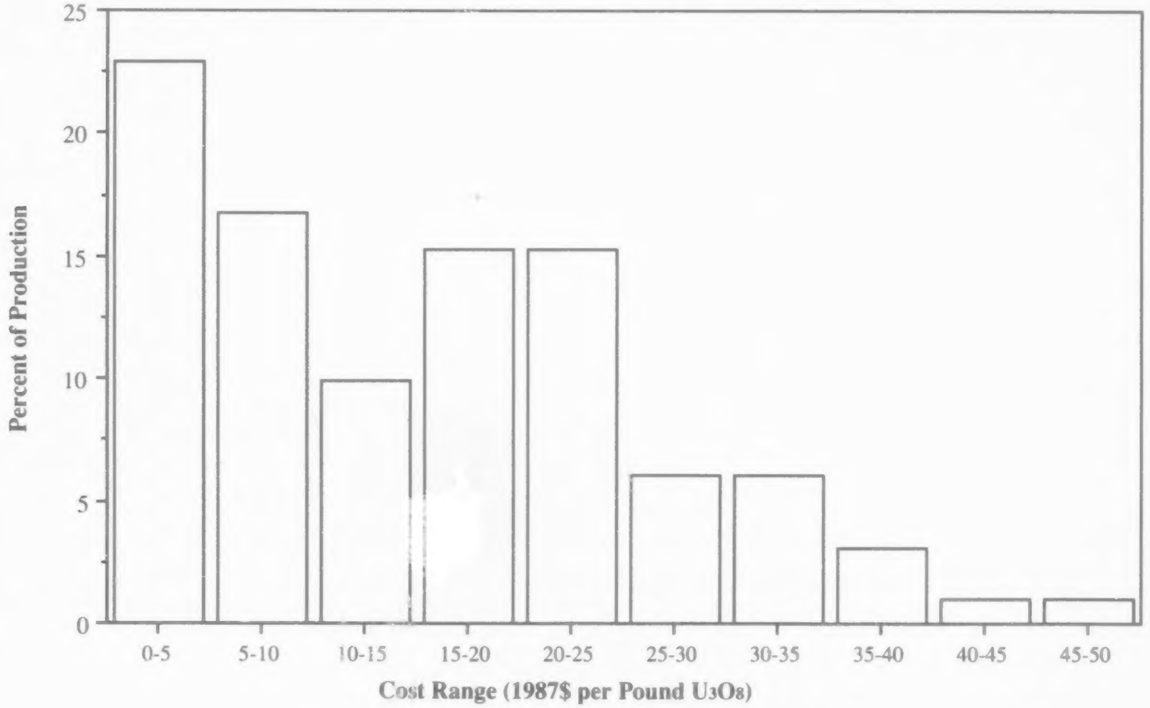


Figure 9
PROJECTED DISTRIBUTION OF FORWARD COSTS

the potential both for easing of export regulations and for the development of new deposits in Australia and Canada, factors especially important because of the large volume of undeveloped uranium resources in those countries.

Future Market Considerations Affecting Producers

The central problem facing the world's producers is that of surviving until better times. Although some producers have favourable long-term contracts to help them through the expected transition period, their production costs must be competitive over the long term to assure their survival. Having a low relative production cost is the best assurance of viability in the long term.

From a utility's perspective, the basic objective of a uranium procurement programme is to obtain a sufficient supply of uranium at a reasonable cost and with adequate assurance and flexibility of supply. A balance often must be drawn between cost and security of supply. Also, a well-designed procurement programme will allow for flexible response to changing market conditions. In the coming marketplace, producers will have offer to buyers three very important features in order to be successful. These features are flexibility in quantity, delivery schedule, and price.

The degree of flexibility offered by suppliers of enrichment services has a clear effect. Led by the US Department of Energy (DOE), nearly all of the primary enrichers are offering "requirements" contracts, generally having variable tails assay options. That is, enrichment contracts specify that the customers may adjust their purchases of enrichment services to match their reactors' requirements, or a stated fraction thereof. Given this flexibility, utilities also want flexibility in their natural uranium and UF_6 conversion contracts. One sign of this buyer objective is that new uranium contracts today typically offer a 20-percent flexibility in quantities to be supplied under such contracts. Prices frequently are partially or entirely related to market indices, and deliveries are allowed to stretch out over several months.

Risk aversion also is an important force influencing utilities' desire for flexibility — in quantities, delivery schedules, and prices. Utilities with large nuclear power programs frequently and wisely rely on several suppliers and several price mechanisms. For example, a utility might have several uranium supply contracts in place for each year's requirements, each with a 20-percent optional quantity above and below a stated amount. This type of arrangement would give the utility a great deal of maneuvering room to respond to the most economical enrichment tails assay, achieve the lowest overall price (including the option of purchasing in the spot market), and limit the impact of nonperformance by one of the suppliers.

Another type of flexibility desired by utilities is the right to terminate contracted deliveries in the event of unforeseen delays or prolonged shutdowns of the covered reactor or, in the USA, in the event that the material to be supplied becomes restricted from use in their reactors, because of origin or other factors. The latter factor is, or course, very important to non-US producers attempting to sell to US companies.

Finally, utilities in this buyers' market are highly sensitive to pricing terms. Many sellers for intermediate-term delivery have been successful by offering "market-related" prices (usually discounts from the spot price) with no price floors. In the USA, such pricing terms are encouraged by the nature of electricity price regulation, in which utilities paying uranium prices higher than the spot market price may not be allowed to pass on all such costs to the consumers, while utilities paying less than the spot price are not rewarded for their foresight. In Europe, utilities are relying to a greater extent than ever before on spot market purchases, although the quantities of such purchases still are much smaller than deliveries under older long-term contracts.

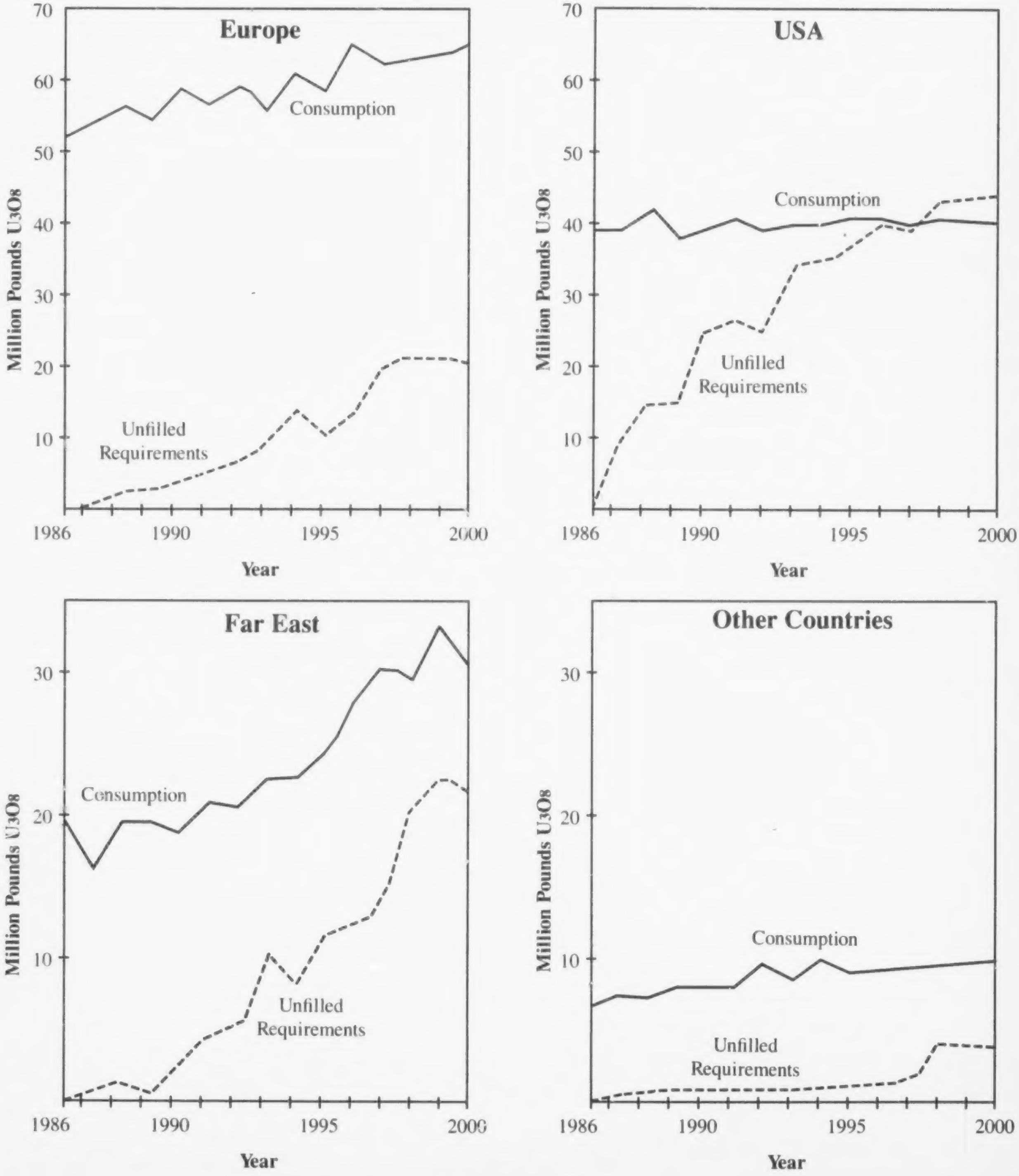
Conclusion

The current buyers' market is expected to continue at least for a few years, an outlook that is not welcome news for the world's uranium producing industry. This expectation, together with the state of maturity of utility nuclear fuel management and procurement practices, will continue to encourage competition in the uranium industry. Assuming free market conditions in the future, we expect that production costs required to balance supply and demand will have to be above current spot market prices but well below those of the late 1970s (in constant US dollars). During this period (as in any other buyers' market), producers will have to keep production costs very low in order to be able to compete and will have to be very imaginative in their offering of price, delivery-schedules and quantity flexibility terms.

Of course, the development of an effective restricted market in the USA could cause a major change in this outlook, to the benefit of US producers and the detriment of non-US producers. The degree of this benefit to US producers will be determined by the level of restrictions, US inventory levels, and (most of all) the extent to which DOE will accept grandfathered, swapped, or exchanged material for enrichment and subsequent use in US-utilities' reactors.

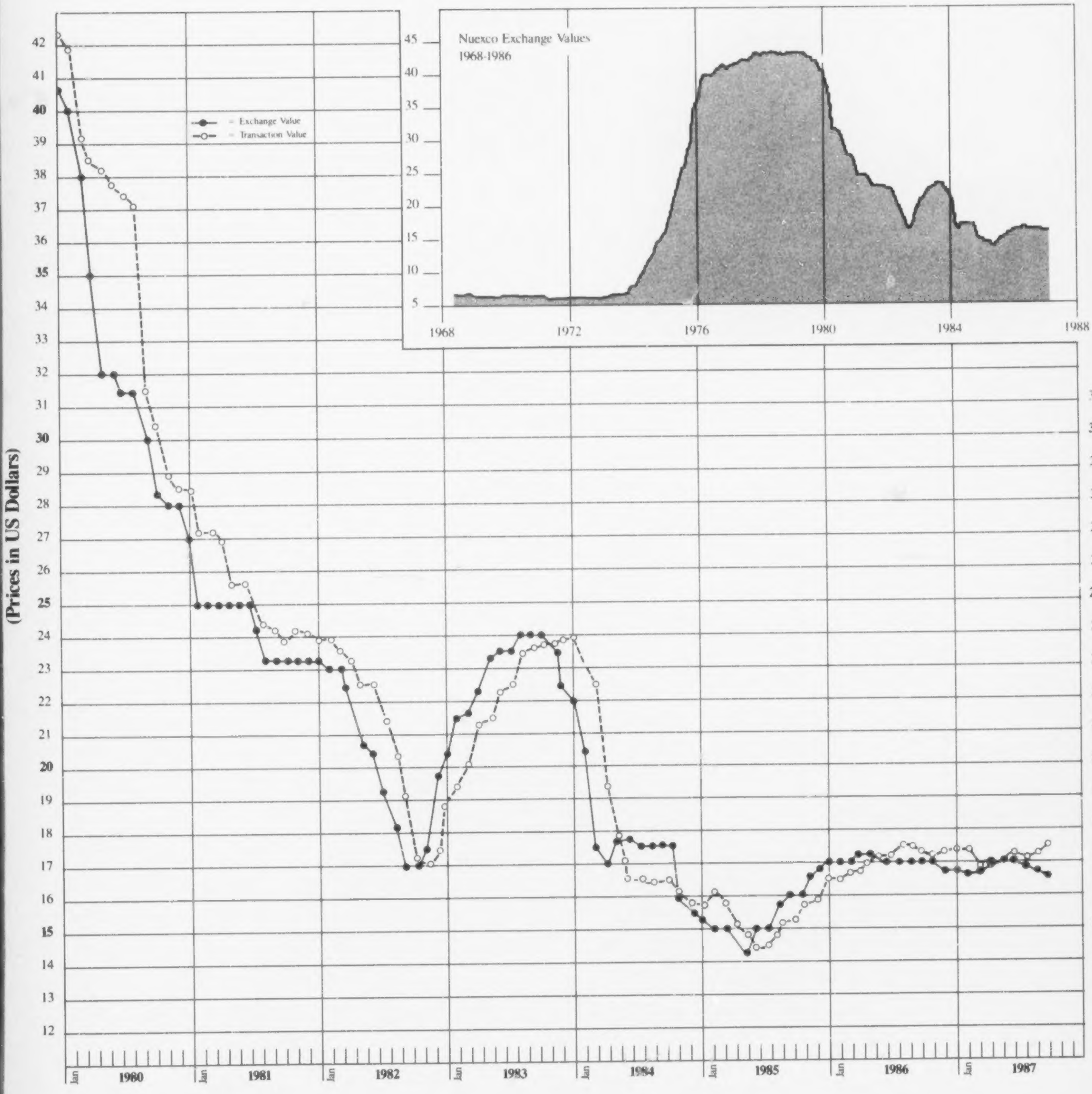
© NUEXCO 1987

Figure 10
TOTAL CONSUMPTION AND UNFILLED REQUIREMENTS, BY REGION



© NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969		6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	**16.65**				

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.30	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.05	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	**17.55**				

©NUEXCO 1987

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	**1.90**				

HISTORICAL UF_6 VALUES

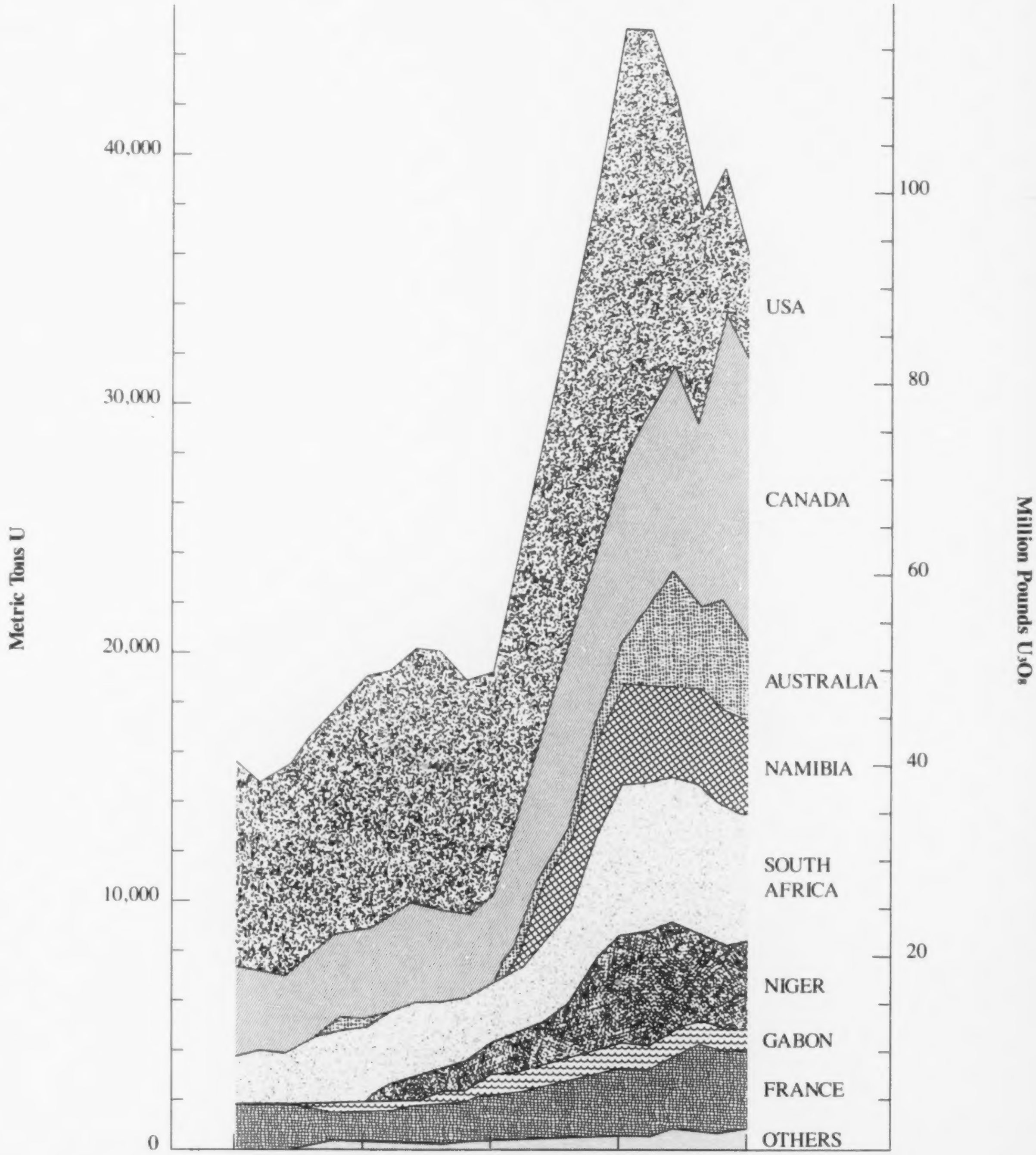
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	**47.00**				

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium (\$/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	\$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	\$28.15[5]	3.6	\$43.10	5.8
1981	38.5	32.6[5]	\$34.65[5]	6.6	\$32.90	4.4
1982	26.9	27.1	\$38.37	17.1	\$27.23[6]	6.2
1983	21.2	24.2	\$38.21	8.2	\$26.16	3.3
1984	14.9	22.5	\$32.65	12.5	\$21.86	2.2
1985	11.3	21.7	\$31.43	11.7	\$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

© NUEXCO 1987

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4] Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2]	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1976 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
1984 Avg.	133.6	95.3	194.1
1985 Ave.	142.6	100.0[4]	203.2
1986 Avg.	155.5	104.9[4]R	213.7
Jan 1986	—	109.5R	211.2
Feb 1986	—	108.7	211.2
Mar 1986	150.5	99.4R	211.2
Apr 1986	—	94.2R	211.2
May 1986	—	93.5	211.2
Jun 1986	153.0	95.6R	211.2
Jul 1986	—	97.9R	216.0
Aug 1986	—	98.1R	216.0
Sep 1986	157.0	105.5R	216.0
Oct 1986	—	106.0R	216.1
Nov 1986	—	105.0R	216.3
Dec 1986	161.5	105.4R	216.2
Jan 1987	—	106.3R	216.2
Feb 1987	—	109.1R	216.5
Mar 1987	164.7	108.5P	217.0
Apr 1987	—	108.4P	—

P = Preliminary R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0).

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index is 1968/1069 = 100 for years 1975-1983, and 1984/1985 = 100 for all subsequent data.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Basis is 1975 = 100 for years 1975-1978, and 1976 = 100 for all subsequent data.

[4] Annual averages are for financial year ending June 30.

[5] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

©NUEXCO 1987

CANADA

		Industry Products Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
			Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979	Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980	Avg.	247.2	—	10.58	10.80	—	—	8.50
1981	Avg.	288.7	—	12.02	12.23	—	—	9.53
1982	Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983	Avg.	298.8	—	—	14.30	—	—	11.17
1984	Avg.	310.9	17.88	—	—	—	—	—
Jan	1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb	1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar	1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr	1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May	1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun	1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul	1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug	1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sept	1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct	1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov	1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec	1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan	1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb	1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar	1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr	1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May	1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun	1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul	1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug	1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep	1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct	1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov	1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec	1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan	1987	120.0	19.53	16.93	16.01	13.06	12.58	12.89
Feb	1987	119.8	20.33	17.20	16.21	13.01	12.66	13.11
Mar	1986	120.3	20.04	17.14	16.15	13.57	12.58	13.02
Apr	1987	121.1	20.47	17.38	16.26	13.75	11.99	13.27
May	1987	122.0R	20.50	17.12R	15.96R	14.23R	11.44R	13.19R
June	1987	122.3P	20.41P	17.09P	15.76P	13.94P	12.82P	12.90P

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: “Industry Price Indexes” (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as “Manufacturing.” Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: “Employment, Earnings and Hours” (3Reports 175 through 185 list this series title incorrectly as “Metal Mining, Including Milling (SIC 050-099)“Æ Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, plus a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data. Wage Earner Data were further revised in January 1987 and now reflect a slightly different base than previously.

[3] Reports 175 through 185 list this series title incorrectly as “Metal Mining, Including Milling (SIC 050-099).”

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI data for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled “Metal Mining, Including Milling (SIC 050-099)“ should read “Total Mining (SIC 051-099)”.

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.[7]	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.88	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.76	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	757,872R	598,986R
Mar	1987	88.17	197.1	255.0	239.6	762,697	536,006
Apr	1987	—	—	258.2	242.5	759,714	531,771
May	1987	—	—	261.2	243.6	—	—
Jun	1987	90.74	203.5	263.1	244.9	—	—
July	1987	—	—	266.2			

P = Preliminary R = Revised since last month

---

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

UNITED STATES

		Producer Price Index[1]		Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
		Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.[6]	304.1	293.4	272.4	195.51	11.55	11.98	9.96	8.21
1981	Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982	Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983	Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984	Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985	Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan	1986	323.8	308.9	328.4	—	13.41	13.68	11.87	9.58
Feb	1986	318.9	304.4	327.5	—	13.46	13.80	11.83	9.57
Mar	1986	314.0	300.3	326.0	113.5	13.41	13.91	11.80	9.60
Apr	1986	311.6	298.2	325.3	—	13.47	13.89	11.84	9.60
May	1986	311.6	299.2	326.3	—	13.40	13.79	11.90	9.63
Jun	1986	311.8	299.0	327.9	114.2	13.50	13.50	11.95	9.59
Jul	1986	308.5	297.4	328.0	—	13.33	13.30	12.05	9.67
Aug	1986	307.9	297.2	328.6	—	12.96	13.13		9.64
Sep	1986	308.7	297.5	330.2	115.0	13.04	13.28	12.03	9.70
Oct	1986	309.6	298.4	330.5	—	12.85	13.16	12.08	9.67
Nov	1986	309.8	298.7	330.8	—	12.75	13.14	12.17R	9.73
Dec	1986	309.3	298.1	331.1	115.3	12.70	13.03	12.20	9.82
Jan	1987	313.6	300.9	333.1	—	12.94	12.98	12.18	9.84
Feb	1987	314.9	302.2	334.4	—	12.99	12.83	12.21	9.84
Mar	1987	315.7R	302.7R	335.9	116.2	13.04	12.79	12.24	9.84
Apr	1987	317.4	305.1	337.7	—	13.16	12.90R	12.30	9.82
May	1987	318.6	307.3	338.7	—	12.97R	12.92P	12.31R	9.83
Jun	1987	320.2	308.5	340.1	117.2	13.02P	12.93P	12.27R	9.84R
Jul	1987	322.6	310.2	340.8	—	—	—	12.35P	9.87P

P = Preliminary   R = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28 and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139. Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147. Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154. Monthly Data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 829177 (COMAG CH)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR

B6800-1 A-
10/22/87

NUEXCO

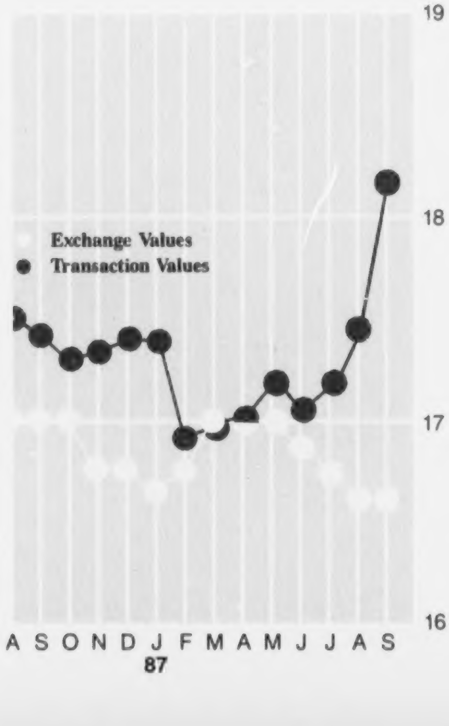
Monthly Report

October 1987 Number 230

Old Shibboleths and New Verities, by George White, Jr. 15

Recent Nuclear Industry Mergers 20

Implications for US Uranium Industry Viability 23



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

CHIEF EXECUTIVE OFFICER — Charles H. Peterson

NUEXCO TRADING CORPORATION

President	Earl E. Hoellen, Jr.
Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan

NUEXCO INFORMATION SERVICES COMPANY

President	R. Gene Clark

Support Services

Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

Hans W. Vogt
(Switzerland)

Chris I. von Christierson
(South Africa)

W. Bryan Webster
(USA)

NUEXCO

NUEXCO REPORT 230 FIGURES OF THE MONTH (September 30, 1987)	This Month (Report 230)	Last Month (Report 229)	12 Months Ago (Report 218)
Exchange Value ($US per pound U_3O_8 equivalent)	16.65	16.65	17.00
US Premium for the Exchange Value (US$ per pound U_3O_8)	2.10	2.35	—
UF_6 Value ($US per kilogram U as UF_6)	46.75	47.00	48.00
US Premium for the UF_6 Value ($US per kgU as UF_6)	4.25	6.00	—
Transaction Value ($US per pound U_3O_8 equivalent)	18.20	17.55	17.35
Loan Rate (Per Annum)	4%	4%	4%
Conversion Value ($US per pound U as UF_6)	1.90	1.90	1.90
Near-Term Uranium Supply[1] (millions of pounds U_3O_8)	6.4	3.7	4.1
Near-Term Uranium Demand[2] (millions of pounds U_3O_8)	1.7	2.0	1.4
Near-Term Supply-Demand Ratio	3.7	1.8	2.9
Recent Uranium Sales:[3]			
Number of Transactions	9	6	4
Quantity of Material (Millions of pounds U_3O_8 equivalent)	19.2	1.6	0.5
Nuexco SWU Value:			
at 0.3 tails assay and delivery within one year ($US per SWU)	73	75	78
US DOE SWU Prices:			
USEC	119.00[4]	119.00[4]	119.00[5]
AFC	153.00[6]	153.00[6]	153.00[6]
Requirements	157.00[6]	157.00[6]	157.00[6]
Incentive Price	90.00[7]	90.00[7]	—
Market Value of Enriched UF_6[8]: ($US per kgU as UF_6)			
2.5 w/o U_{235}	441	446	458
3.0 w/o U_{235}	563	570	586
3.5 w/o U_{235}	688	697	717
4.0 w/o U_{235}	814	825	849

---

[1] Active inquiries to sell, for delivery within 12 months after contract signing.

[2] Active inquiries to purchase, for delivery within 12 months after contract signing.

[3] Uranium sales only; does not include loans, conversion, or SWU transactions.

[4] Effective since 10/1/86; scheduled to drop to $117 on 10/1/87.

[5] Effective since 10/1/85.

[6] Effective since 10/1/84.

[7] Effective since 10/1/86, for up to 30% of annual requirements.

[8] Calculated using the Nuexco Exchange Value, Conversion Value, SWU Value and 0.30 percent tails assay.

©NUEXCO 1987

NUEXCO

EXECUTIVE SUMMARY
REPORT 230
(All data as of September 30, 1987)

Exchange Value
$16.65, unchanged

The **Exchange Value** is **$16.65** per pound U_3O_8, unchanged since last month.The US Premium (relative to the Exchange Value) is $2.10, down $0.25 since last month.

UF_6 Value
$46.75, down $0.25

The **UF_6 Value** is **$46.75** per kilogram U as UF_6, down $0.25 since last month.The US Premium (relative to the UF_6 Value) is $4.25, down $1.75 since last month.

Transactions

Nine recent natural uranium sales are reported, involving **19 million** pounds equivalent U_3O_8. Five of the sales involved spot or near-term delivery, and three met the conditions for inclusion in the Transaction Value. Active spot and near-term **uranium supply** amounts to **6.4 million** pounds U_3O_8 equivalent, up 2.7 million pounds since last month. Active spot and near-term **uranium demand** totals **1.7 million** pounds, down 300 thousand pounds from last month. The spot and near-term **supply-demand ratio** increased to **3.7 to 1**.

Transaction Value
$18.20, up $0.65

The **Transaction Value** is $18.20 per pound U_3O_8, **up $0.65** since last month. The calculation includes transactions involving a total of 3.2 million pounds U_3O_8 and equivalent UF_6, of which 1.9 million pounds are US-origin, and covers a period of 3 months.

Loan Rate
4%, unchanged

The **Loan Rate** is **4 percent** per annum, unchanged.

Conversion Value
$1.90, unchanged

The **Conversion Value** is **$1.90** per pound U as UF_6, unchanged since last month. Active secondary market supply for conversion services for delivery within three years totals 770 thousand pounds U as UF_6. Active demand totals 440 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

SWU Value for
delivery within
one year: $73,
down $2.00

The **SWU Value** at .3% tails assay and for delivery within one year is **$73** per SWU, down $2.00 since last month. Two secondary market SWU transactions are reported.

* * *

Essay

In this edited version of the speech he gave at the US Council for Energy Awareness' Uranium Seminar at Keystone, Colorado, Mr. George White, Jr. discusses future trends in the uranium industry, stressing the changing nature of contracting practices.

Analysis and
Commentary

The US government recently released some key 1986 statistics concerning the US uranium industry. The industry seems to have reached a "valley" of activity, a fact that has implications for the US Secretary of Energy's upcoming determination of the industry's "viability." Given the criteria used by DOE, and the reported data, it will be difficult to make a case for improvement over the uranium industry's 1985 viability level.

United States

Within the past year, several important nuclear-industry mergers or strategic affiliations have taken place. Kraftwerk Union AG bought Exxon Nuclear Inc. (renamed Advanced Nuclear Fuels) and has announced an alliance with Bechtel Group Inc. to provide nuclear services to the US market. A French consortium of Framatome, Cogema Inc. and Uranium Pechiney has announced a joint-venture agreement with Babcock & Wilcox for nuclear fuel marketing, and Sweden's ASEA and Brown Boveri BBI of Switzerland are preparing to merge the two companies' operations.

* * *

Despite the refusal of the State of Massachusetts to participate in emergency planning for New Hampshire's Seabrook nuclear plant, Seabrook continues to move toward NRC approval of its low-power license.

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

October 1987 No. 230

R. GENE CLARK, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING

Nuexco Market Values Table 1
Natural Uranium and Conversion 2
Enriched Uranium and SWU 5

CURRENT MARKET DATA

Nuexco Market Values Expressed in Selected Currencies 6
Recent Transactions 8
Supply and Demand Tables 10

ESSAY

Old Shibboleths and New Verities 15

RECENT DEVELOPMENTS

United States 20

ANALYSIS AND COMMENTARY

The US Uranium Industry in 1986: Implications for Viability 23

HISTORICAL MARKET DATA

Graph of Exchange Value and Transaction Value 37
Historical Exchange Values and Transaction Values 38
Historical Conversion Values and UF6 Values 39
Graph of World Uranium Production 40
US Uranium Marketing Activities Statistics 41
Volume and Price of Uranium Deliveries to the European Community . . 42

GOVERNMENT STATISTICS

Australia 43
Canada 44
South Africa 45
United States 46

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

To Our Readers

* * *

Nuexco Information Services is pleased to announce the addition of Thomas C. Pool to its staff. He will be responsible for the analysis of uranium production, including source, quantity, schedule and cost. Since graduating from Colorado School of Mines in 1968 in mining engineering, Tom has worked extensively in mining and construction, on a worldwide basis. He has wide experience in the uranium industry, focusing on mineral valuation, cost and feasibility studies. Tom comes to Nuexco from Douglas-Robertson, Consulting Engineers and Geologists, where he was a Vice-President and Director.

©NUEXCO 1987

NUEXCO

September 30, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$16.65**/lb. U_3O_8	6,435	1,725
US Premium	**$2.10**		
UF_6 VALUE	**$46.75**/kgU		
US Premium	**$4.25**		
CONVERSION VALUE	**$1.90**/lb. U as UF_6	770	440
SWU VALUE **0.3 tails assay:** **delivery within one year**	**$73**/SWU	200	70
LOAN RATE	**4%**/annum	1,100	250

TRANSACTION VALUE

$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
18.20	3.2	14	3

[1] Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Values** represent Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

7. **The US Premium** is Nuexco's judgment of the incremental price (relative to the Exchange Value or UF_6 Value, as applicable) at which transactions for significant quantities of natural uranium could be concluded as of the date indicated, if the buyer will accept only US-origin.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed awillingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of September 30, 1987)

The **Exchange Value** is **$16.65** per pound U_3O_8, unchanged since last month. US-origin uranium is commanding a **premium** (relative to the Exchange Value) of **$2.10** per pound U_3O_8 (down $0.25) in the form of concentrates, and $4.25 per kilogram U (down $1.75) in the form of UF_6. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **6,435,000** pounds U_3O_8 equivalent, up 2.7 million pounds since last month. The corresponding figure for **active demand** is **1,725,000** pounds, down 300 thousand pounds. The spot and near-term supply-demand ratio increased to 3.7 to 1.

The Current Market Data section of this Report lists nine natural uranium sales, totaling 19.1 million pounds U_3O_8 equivalent.

The **Transaction Value** is $18.20 per pound U_3O_8, up $0.65 since last month. The calculation extends over a 3-month period and includes 14 transactions involving 3.2 million pounds equivalent U_3O_8.

The **UF_6 Value** is $46.75 per kilogram U in UF_6, down $0.25 since last month. Three transactions involving UF_6 are reported, totaling approximately 550 thousand pounds equivalent U_3O_8. Demand for UF_6 remains weak.

The **Conversion Value** is $1.90 per pound U as UF_6, unchanged since last month. Active supply of secondary market conversion services totals 770 thousand pounds U as UF_6. Active demand totals 440 thousand pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is 4 percent per annum, unchanged since last month.

* * *

The Exchange Value remained at $16.65 per pound U_3O_8 as of the end of September, and the Premium (relative to the Exchange Value) for US-origin declined to $2.10 per pound U_3O_8 (down $0.25), reflecting a slight weakening of prices in the near-term market for US-origin concentrates. Despite a moderate degree of activity in the USA in September, the lack of significant firm near-term demand in the USA and Europe is preventing any rise in prices.

Two spot U_3O_8 transactions are reported this month, involving US utilities buying approximately 500 thousand pounds of US-origin material. Three UF_6 transactions, involving approximately 550 thousand pounds U_3O_8 equivalent, also are reported. In addition, four longer-term U_3O_8 sales are reported, totaling approximately 18 million pounds. Two of these longer-term transactions involved US utilities' purchases of non-US-origin material, while the remaining two involved a single non-US utility buying from both Canadian and Australian suppliers.

Active supply of natural uranium has increased since last month, as several sellers have either increased their presence in the market, or have reentered it. US producers generally have maintained their asking prices at or above the $20 level for significant quantities of material since the Appeals Court ruling of July 20, 1987. However, a limited amount of US-origin U_3O_8 from the inventories of non-US utilities may be available at lower prices. Canadian sellers are becoming more aggressive, especially where they are able to compete for business without being hindered by the federal government upgrading policy, although there was little evidence of price cutting in September. While some observers believe that little uncommitted Canadian supply is available for the remaining months of 1987, it is likely that additional quantities could be made available on fairly short notice. However, spot demand is largely concentrated in the 1988 delivery period.

Several US utilities are in the market for spot or near-term supplies, totaling about 1.5 million pounds U_3O_8 equivalent. Near the end of the month, two US buyers entered the market seeking a substantial quantity of material both for 1988 and longer-term delivery. While firm demand is likely to materialize in 1988, current active spot market demand remains weak.

The UF_6 Value declined $0.25 this month, to $46.75, reflecting a somewhat greater abundance of UF_6 in the market. The Premium (relative to the UF_6 Value) for US-origin UF_6 is $4.25, a sharp drop from the $6.00 of last month. Much of the US-origin material currently moving through the market is UF_6 which had been held by non-US utilities, many of which are willing to swap their unneeded US-origin uranium, releasing additional US-origin UF_6 on the market. Conversely, US producers continue to hold on to their stocks of US-origin U_3O_8. As a consequence, the premium for US-origin UF_6 has weakened more than the premium for US-origin U_3O_8.

In Europe, most existing demand is for UF_6, especially for origins not covered by end-use restrictions, which may

©NUEXCO 1987

carry slightly higher prices. Adequate supply of UF_6 exists in Europe and as of the end of September, one utility was reported to be near concluding a transaction for a significant quantity of UF_6. In addition, at least two European utilities have expressed an interest in purchasing on the spot market, while several others may be poised to enter the market in the near future.

Since there is no certainty of immediate restrictions on DOE enrichment of non-US-origin feed, US utilities holding excess US-origin material may even be considering swapping or selling that material. There are several factors that can be expected to have a major impact on buying and selling decisions, including:

1. The probability of a court-ordered import restriction, as ordered by the Federal District Court in Denver and upheld by the Tenth Circuit Court of Appeals in the US Producers vs. DOE lawsuit. Such a scenario makes US-origin natural uranium more valuable for DOE enrichment contract holders, but there would be no premium on enriched product. In the absence of usage restrictions, US-origin material ceases to carry a premium once it is enriched. Until legal or legislative actions make enriching US-origin uranium more or less compulsory, there are strong reasons for withholding enrichment of US-origin, possibly substituting non-US-origin as long as possible.

2. The possibility of passage of Senator Domenici's draft legislation, which might require US utilities to limit their actual use of non-US-origin uranium, with scaled penalties for use of non-US-origin beyond a specified percentage. Such a restriction could lead to a premium on both natural and enriched US-origin uranium.

3. The possibility of a US-Canada free-trade agreement, which could make Canadian and US-origins of essentially equal value in the USA.

In the USA, several potential buyers remain cautious, waiting for the uncertainty surrounding the status of the US Producers vs. DOE lawsuit to diminish before making firm procurement plans. As of the end of September, DOE was continuing to accept non-US-origin feed for enrichment for US reactors. October 18, however, marks the date (unless extended) by which DOE must formally file its petition for *writ of certiorari* to the Supreme Court for review of the case, if it chooses to follow that legal avenue. Many observers speculate that DOE will take its case to the Supreme Court, although some doubt that the Supreme Court will be willing to consider the case, since it has no real constitutional or social ramifications. After its July 20, 1987 ruling upholding Judge Carrigan's June 1986 decision in favor of the producers, the US Tenth Circuit Court of Appeals had not, until early October, responded to DOE's emergency motion for stay of the ruling and to the various briefs filed by, or in support of, both sides in the case. The Appeals Court now has granted DOE a stay until November 7, 1987.

In addition to concern over the outcome of the US producers' lawsuit against DOE, uranium market participants worldwide have been closely watching the trade discussions taking place between representatives of the USA and Canada. The government of Canada (as well as Australia) has issued several strong statements of concern over the possible outcome of a DOE restriction on enrichment of its uranium destined for US reactors. The possibility of a restriction added to the difficulties of negotiating a comprehensive trade agreement with Canada, which many other nations see as a prototype for US trade agreements in the future, since Canada is the USA's largest trading partner.

On October 5, President Reagan notified the US Congress that he intends to enter into a Free Trade Agreement (FTA) with Canada on January 3, 1988. This was the last date that such notification could be given under the Trade Act of 1974, as extended by the Trade Agreement Act of 1979, which has special provisions for "fast-track" ratification by Congress of such agreements. As initialed by the US and Canadian negotiators, Canada will eliminate its current requirement of exporting uranium to the USA only in the most upgraded form possible and the USA will exempt Canadian uranium from possible enrichment restrictions under Section 161(v) of the US Atomic Energy Act. Section 161(v) states that the US DOE shall not enrich non-US-origin uranium for US end use to the extent necessary to maintain a viable US uranium industry.

Although no formal procedures are proscribed for Congressional action between October 5 and January 3, the US Trade Representative probably will initiate an informal consultation process with Congress. During this period the concerns and wishes of both houses of Congress, through Committees (primarily the Senate Finance Committee and the House Ways and Means Committee), and of individual Congressmen and Senators will be made known to the US trade negotiators and the White House. If the Reagan administration wants ultimate ratification of the FTA by Congress, it may have to try to accomodate some of the expressed Congressional concerns and then attempt to obtain Canada's concurrence of modifications of the FTA

©NUEXCO 1987

prior to January 3. At this writing, Congress has refused to provide the President with comments on the summary draft submitted to them and will not do so until the text of the full FTA is provided. The Reagan Administration expects to provide the full text by the end of October. A similar process is ensuing between Prime Minister Mulroney and the Canadian Parliament. Thus, the governments of Canada and the USA have until January 3, 1988, to accomodate the views of their respective legislative branches and agree on the final text of the FTA.

On January 3, Prime Minister Mulroney and President Reagan plan to sign the FTA, which can thereafter become effective only after ratification by the Canadian Parliament and the US Congress. After the President signs the FTA, he must submit to the Senate and House the final full text of the FTA, a draft of an implementing bill, a statement of any proposed administrative action to implement the FTA, and an explanation of how the implementing bill and proposed administrative action affect existing laws. Further, he must submit a statement explaining how the FTA benefits the USA and why the implementing bill and proposed administrative action is required or appropriate.

This package will likely be submitted to both houses of Congress shortly after Congress is back in session in January 1988. The implementing bill will be referred primarily to the Senate Finance Committee and to the House Ways and Means Committee. The Committees may not amend the bill but may only debate it and report it out to the full Senate and House of Representatives within 45 legislative days following submission. Thereafter each house of Congress has 15 legislative days in which to take a final vote on the implementing bill. If and when the implementing bill is enacted into law, the FTA comes into force with respect to the USA.

Given the nature of this rather complex procedure, final Congressional approval of the FTA may not take place until late Spring 1988. Further, the so called "fast-track" procedures that are involved in the enactment of the FTA are pursuant to rules of each house of Congress and accordingly may be modified relatively easily as with any of their other rules. The success or failure of the ultimate establishment of the FTA will undoubtedly depend largely on the ability of the US Trade Representative and the White House to work with Congress

If the treaty is ratified and Canadian uranium producers gain unrestricted access to the US market, regardless of restrictions applied to uranium of other origins, demand for US-origin material could be expected to decline dramatically.

* * *

Beginning in February 1987, the Transaction Value has risen at a steady rate, and now is substantially higher than the Exchange Value. Since the Transaction Value is a weighted average of price and quantity, and is based on all origins of uranium, the recent increase in percentage of transaction volume involving generally higher-priced US-origin has caused the Transaction Value and the Exchange Value to diverge. The Transaction Value also is calculated according to contract price, and is not adjusted to reflect extended payment terms or other conditions that have become increasingly more common. As long as the Transaction Value calculation includes a substantial percentage of US-origin deals, with uranium bought at prices approximating the Exchange Value plus the US Premium, the Transaction Value is likely to remain above the Exchange Value level.

* * *

The Loan Rate remained unchanged this month, at 4 percent per annum. The market for loans has been relatively inactive this month, and no loan transactions are reported, although two parties are reported to be close to concluding a transaction for US-origin U_3O_8.

* * *

The Conversion Value is unchanged this month. Overall, the secondary market for conversion services remains thin. In Europe, the relatively smaller supply of UF_6 has led to a proportionately smaller supply of secondary market conversion, since secondary market conversion is most often obtained through exchanges of U_3O_8 and UF_6. In addition, high primary conversion prices and the relative weakness of the US dollar versus various European currencies are factors acting to keep secondary market prices higher than those in North America. In the USA, a relative surplus of US-origin UF_6 has created the possibility of bargain-priced conversion for holders of US-origin U_3O_8 through deconversion swaps, but only in cases where all necessary conditions, such as origin of material, match closely.

©NUEXCO 1987

ENRICHED URANIUM AND SWU

The SWU Value declined slightly this month, to $73 per SWU. Demand for large quantities of secondary market SWU continues to be weak, although two buyers have shown interest in making small purchases. Two SWU transactions are reported this month, involving US and non-US utilities, both for small quantities. Another US utility currently is evaluating offers. Although some US utilities continue to evaluate the market for short-term delivery, much of the interest appears to come from a need to ascertain their options should DOE be unable to enrich their non-US-origin feed.

The SWU market continues to exhibit a wide range of prices depending on origin, location and various risk factors. The drop in SWU Value to $73 reflects the downward price pressure exerted by the presence and activity of the lower-priced SWU sellers, including the presence of Techsnabexport (USSR) SWU. SWU selling at the lower end to the middle of the market may, however, be considered relatively high-risk for US utilities' use, and is often found contained in enriched uranium product that may not match the buyers' product assay requirements.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Sep 30, 1987)**	**Last Month (Aug 31, 1987)**	**12 Months Ago (Sep 30, 1986)**	**This Month (Sep 30, 1987)**	**Last Month (Aug 31, 1987)**	**12 Months Ago (Sep 30, 1986)**
Australia (dollar)	23.16	23.41	27.06	60.20	60.86	70.34
Belgium (comm. franc)	635.74	627.59	714.29	1,652	1,632	1,857
Canada (dollar)	21.83	21.94	23.58	56.75	57.05	61.32
EEC (ecu)	14.75	14.61	—	38.34	37.99	—
Finland (markka)	73.48	73.25	83.37	191.02	190.44	216.75
France (franc)	101.96	100.73	112.29	265.07	261.86	291.92
FRG (mark)	30.63	30.16	34.32	79.64	78.42	89.21
Italy (lira)	22,112	21,845	23,800	57,485	56,791	61,873
Japan (yen)	2,437	2,363	2,608	6,335	6,144	6,780
Netherlands (guilder)	34.48	33.99	38.90	89.64	88.38	101.14
South Africa (rand)	34.51	33.91	37.53	89.71	88.16	97.56
Spain (peseta)	2,026	2,031	2,269	5,268	5,281	5,900
Sweden (krona)	107.07	106.19	117.48	278.37	276.06	305.43
Switzerland (franc)	25.46	24.85	27.81	66.19	64.61	72.31
UK (pound)	10.22	10.19	11.85	26.58	26.50	30.80
US (dollar)	16.65	16.65	17.00	43.29	43.29	44.20

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
Country (currency)	**This Month (Sep 30, 1987)**	**Last Month (Aug 31, 1987)**	**12 Months Ago (Sep 30, 1986)**	**This Month (Sep 30, 1987)**	**Last Month (Aug 31, 1987)**	**12 Months Ago (Sep 30, 1986)**
Australia (dollar)	25.31	24.68	27.61	65.81	64.15	71.79
Belgium (comm. franc)	694.92	661.52	728.99	1,807	1,720	1,895
Canada (dollar)	23.86	23.13	24.07	62.03	60.13	62.58
EEC (ecu)	16.12	15.40	—	41.91	40.04	—
Finland (markka)	80.32	77.21	85.09	208.81	200.73	221.22
France (franc)	111.45	106.17	114.60	289.75	276.02	297.93
FRG (mark)	33.49	31.79	35.02	87.06	82.66	91.05
Italy (lira)	24,170	23,025	24,290	62,837	59,861	63,147
Japan (yen)	2,664	2,491	2,661	6,925	6,476	6,919
Netherlands (guilder)	37.69	35.83	39.70	97.98	93.15	103.22
South Africa (rand)	37.72	35.74	38.30	98.06	92.92	99.57
Spain (peseta)	2,215	2,141	2,316	5,758	5,566	6,021
Sweden (krona)	117.04	111.93	119.90	304.28	290.98	311.72
Switzerland (franc)	27.83	26.19	28.39	72.35	68.10	73.80
UK (pound)	11.18	10.74	12.09	29.05	27.93	31.43
US (dollar)	18.20	17.55	17.35	47.32	45.63	45.11

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

©NUEXCO 1987

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF6 This Month (Sep 30, 1987)	per lb. U as UF6 Last Month (Aug 31, 1987)	per lb. U as UF6 12 Months Ago (Sep 30, 1986)	per kg. U as UF6 This Month (Sep 30, 1987)	per kg. U as UF6 Last Month (Aug 31, 1987)	per kg. U as UF6 12 Months Ago (Sep 30, 1986)
Australia (dollar)	2.64	2.67	3.02	5.83	5.89	6.67
Belgium (comm. franc)	72.55	71.62	79.83	159.94	157.89	176.00
Canada (dollar)	2.49	2.50	2.64	5.49	5.52	5.81
EEC (ecu)	1.68	1.67	—	3.71	3.68	—
Finland (markka)	8.38	8.36	9.32	18.49	18.43	20.54
France (franc)	11.64	11.49	12.55	25.65	25.34	27.67
FRG (mark)	3.50	3.44	3.84	7.71	3.52	8.46
Italy (lira)	2,523	2,493	2,660	5,563	5,496	5,864
Japan (yen)	278.06	269.69	291.46	613.02	594.57	642.55
Netherlands (guilder)	3.93	3.88	4.35	8.67	8.55	9.59
South Africa (rand)	3.94	3.87	4.19	8.68	8.53	9.25
Spain (peseta)	231.23	231.79	253.64	509.77	511.01	559.17
Sweden (krona)	12.22	12.12	13.13	26.94	26.71	28.95
Switzerland (franc)	2.91	2.84	3.11	6.40	6.25	6.85
UK (pound)	1.17	1.16	1.32	2.57	2.56	2.92
US (dollar)	1.90	1.90	1.90	4.19	4.19	4.19

SWU VALUE AND UF6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU Value delivery within one year (Sep 30, 1987)	UF6 Value per kg.U in UF6 This Month (Sep 30, 1987)	UF6 Value per kg.U in UF6 Last Month (Aug 31, 1987)
Australia (dollar)	101.53	65.02	66.08
Belgium (comm. franc)	2,787	1,785	1,772
Canada (dollar)	95.70	61.28	61.93
EEC (ecu)	64.66	41.41	41.25
Finland (markka)	322.15	206.31	206.77
France (franc)	447.03	286.28	284.33
FRG (mark)	134.31	86.01	85.14
Italy (lira)	96,946	62,085	61,664
Japan (yen)	10,683	6,842	6,671
Netherlands (guilder)	151.17	96.81	95.95
South Africa (rand)	151.30	96.89	95.72
Spain (peseta)	8,884	5,689	5,734
Sweden (krona)	469.45	300.64	299.74
Switzerland (franc)	111.62	71.48	70.14
UK (pound)	44.83	28.70	28.77
US (dollar)	73.00	46.75	47.00

---

[1] Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

©NUEXCO 1987

CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4151	1990 on	5,001-10,000	R[3]	Producer	Utility	
4153	1992-99	1,501-3,000	R[3]	Producer	Utility	
4154	1992-99	1,501-3,000	R[3]	Producer	Utility	
4161	1988	101-300	108-112	Producer	Utility	US-Origin
4162	1988	101-300	R[3]	R[3]	Utility	US-Origin
4163	1993 on	5,001-10,000	R[3]	Producer	Utility	
4166	1989	101-300	103-107	Intermediary	Utility	UF_6
4167	1987	301-600	93-97	Intermediary	Utility	US-Origin UF_6
4168	1987	50-100	93-97	R[3]	Utility	UF_6

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.

[3] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.

©NUEXCO 1987

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price Range as Percent of Current C.V.	Seller	Buyer	Remarks
4164	1988	101-300	113-117	Intermediary	Utility	

Nuexco Transaction Number	Delivery Period	Approximate Quantity[3] (thousands of SWU)	Approximate Price Range as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4152	1988	less than 50	93-97	Intermediary	Utility		
4169	1988	less than 50	98-103	Intermediary	Utility		

---

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.

[2] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.

[3] Prices are usually normalized to 0.30% tails assay. Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

©NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

URANIUM SUPPLY
(September 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
87-1002	770	—	
87-1014A*	[illegible]0	—	UF_6
87-1022	40	—	
87-1023	500	500 per year	1987-90
87-1053*	100	400 per year	1989 on
87-1084C*	125	—	UF_6
87-1091	1,000	1,000 per year	UF_6
87-1097	500	—	
87-1109*	50	250 per year	1990 on
87-1120*	1,000	—	
87-1123*	1,000	—	
87-1124*	500	500 per year	1988 on
87-1130*	750	—	
87-1001	—	400 per year	1989 on
87-1005	—	400 per year	1988-95
TOTAL:	6,435		
INACTIVE			
87-1017	1,000	—	
87-1055	250	300 per year	1988-93
87-1059	120	—	UF_6
87-1061*	780	800 per year	UF_6, 1988 on
87-1019	—	600 per year	1988-91
87-1025	—	250 per year	1988 on
TOTAL:	2,150		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 1047, 1062, 1068, 1079.

© NUEXCO 1987

URANIUM DEMAND
(September 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Spot or Near-term[2]**	**Intermediate or Long-term**	**Remarks**
Inquiries to Purchase: ACTIVE			
87-1057*	175	—	
87-1107*	450	1,225	1990-92
87-1113*	390	—	UF_6
87-1116A*	60	—	UF_6
87-1121*	650	650 per year	1988-96
87-1013	—	1,200 per year	1990-95
87-1021*	—	200 per year	1992 on
87-1049	—	700 per year	1989-96
87-1108*	—	200 per year	1991-2000
TOTAL:	1,725		
INACTIVE			
87-1007	150	—	
87-1030*	175	—	
87-1040	300	300	1989
87-1048	50	—	
87-1073	800	—	UF_6
87-1078*	200	—	
87-1114*	525	—	
87-1125*	100	—	
TOTAL:	2,300		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.

Projects removed since last month: 1070, 1082, 1092, 1095.

© NUEXCO 1987

CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(September 30, 1987)

	Delivery Period[1] (Thousands of Pounds U_3O_8)		
Nuexco Project Number	**Within 1 Year**	**Beyond 1 Year**	**Remarks**
Available for Loan:			
ACTIVE			
87-1064	600	—	
87-1119*	500	—	
TOTAL:	1,100		
INACTIVE			
87-1012	2,000	—	
87-1031	1,000	—	
87-1033	1,000	—	
87-1071	1,000	—	UF_6
TOTAL:	5,000		
Inquiries to Borrow			
ACTIVE			
87-1098	250	—	UF_6
TOTAL:	250		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: None.

©NUEXCO 1987

CONVERSION SUPPLY AND DEMAND
(September 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF$_6$)		Remarks
	Within 3 Years	Beyond 3 Years	
Available for Sale: **ACTIVE**			
87-1122*	330	—	
87-1131*	440	—	
TOTAL:	770	750	
INACTIVE			
87-1008*	750	750	
87-1084C	120	—	
TOTAL:	870		
Inquiries to Purchase: **ACTIVE**			
87-1072	440	—	
TOTAL:	440		
INACTIVE			
87-1132*	220	—	
TOTAL:	220		

*New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: none.

©NUEXCO 1987

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(September 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWU) Spot or Near-term[2]	Delivery Period[1] (Thousands of SWU) Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
87-1068	100	—	1988
87-1096*	100	—	1988
TOTAL:	200		
INACTIVE			
87-1004	55	—	1987
87-1058*	150	—	1987
87-1059	25	—	1987
87-1128	300	—	1987
TOTAL:	530		
Inquiries to Purchase:			
ACTIVE			
87-1100*	55	—	1988
87-1116B*	15	—	1988
TOTAL:	70		
INACTIVE			
87-1065*	150	—	1988
TOTAL:	150		

*New or revised since last month.

[1] Measured from the date of this Report.

[2] For delivery within one year. This category excludes SWU deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 1024, 1042, 1087.

© NUEXCO 1987

ESSAY

OLD SHIBBOLETHS AND NEW VERITIES

This is an edited version of the speech given by Nuexco's George White, Jr. at the U.S. Council for Energy Awareness Uranium Seminar at Keystone, Colorado on September 16, 1987.

I last spoke to this group in 1984, right here in Keystone, Colorado. The thesis advanced then was that the uranium market had fundamentally changed as a consequence of certain events. These events were (a) the adoption by DOE of the US Enrichment Contract, (b) the discovery of new, very high grade uranium deposits, of which Cigar Lake was representative, and (c) the plethora of reactor cancellations. I concluded that it was difficult to make a case for higher uranium prices. This conclusion, while prophetic, was not uniformly popular with the 1984 audience. Today's message may prove equally troublesome to some.

Since late 1980, many industry observers have noted that a return to "normalcy" in the uranium business was dependent on the occurrence of one or more events, including:

— The liquidation of excess inventories;

— The work-down of inventories to levels where new demand would emerge;

— The recognition by buyers that available supplies were tightening as compared with unfilled future requirements.

The concept of "normalcy" is a difficult one. What is normal in the uranium business? I submit that the commercial history of uranium is too short to have established any baseline condition from which to measure. Indeed, if one looks at the uranium market over the past 19 years, it might be argued that the normal condition is one of rather dramatic price movement.

Figure 1 shows the Nuexco Exchange Value and indicates the most consistent thing as 4 years of prices in the range of $6.00 per pound U_3O_8. I don't think anyone would suggest that price level as the norm. Another approach is shown in Figure 2, where the Exchange Value is also shown in 1987 constant dollars. Suffice it to say that we, at least, have been unable to find anything that we feel comfortable defining as normal.

Actually, it seems that "normal" is, in reality, a euphemism for the word "desirable." And, since $100 per pound U_3O_8 prices are desirable for producers and $10 per pound U_3O_8 prices are desirable for utilities, there is little likelihood that buyers and sellers will ever agree on what is normal. If there is no such thing as normalcy, we cannot look forward to its return. What then is the shape of the future market? I believe the uranium market in the years ahead will be driven and characterized by the following:

1. Uranium contracts will be characterized by substantially greater quantity flexibility.
2. Increasing quantities of uranium will be purchased on the spot and near-term markets.
3. Increasing quantities of uranium deliveries will be spot market prices.
4. New commercial and financial tools and techniques will be developed as buyers, sellers and traders of uranium seek ways to shift the business and financial risks associated with the altered market environment.

The trend towards greater quantity flexibility is a natural outgrowth of the other developments in the nuclear fuel cycle. The US enrichment contract is a requirements contract. New conversion contracts are increasingly requirements-based as opposed to providing for fixed quantities. It is hardly surprising that buyers are insisting on equivalent flexibility in their uranium supply arrangements. We should remember that the amount of uranium required is a dependent variable, a function of capacity factors, fuel designs and enrichment considerations.

There are a number of routes available to obtain the desired degree of flexibility. An obvious approach is to build it into individual long-term supply contracts, with provisions that allow the buyer to increase or decrease nominal tonnage. It is not uncommon for buyers to have the right to increase or decrease quantity by 30 percent with 12 months' notice, or by 20 percent with six months' notice. Some contracts use a different approach, whereby the supplier agrees to provide a certain percentage of the buyer's needs, subject perhaps to certain minimum and/or maximum amounts, whatever those needs may be.

A second route involves contracting for firm quantities which are less than the anticipated total requirement, with the specific intention of purchasing the balance in the spot or near-term market when the total quantity needed is actually known. A third route involves relying on the spot and near-term markets for 100 percent of requirements. This approach minimizes the chances of having too much uranium on hand or having it too soon. While reliance on the spot market for 100 percent of requirements has, to date, generally been viewed as too risky and hence inappropriate for the largest nuclear utilities, such strategies have worked very well for other, smaller utilities. And, in an expanded spot market, the larger utilities could well increase their participation in the spot market, particularly if they mitigate the risk with some extra inventory.

© NUEXCO 1987

ESSAY

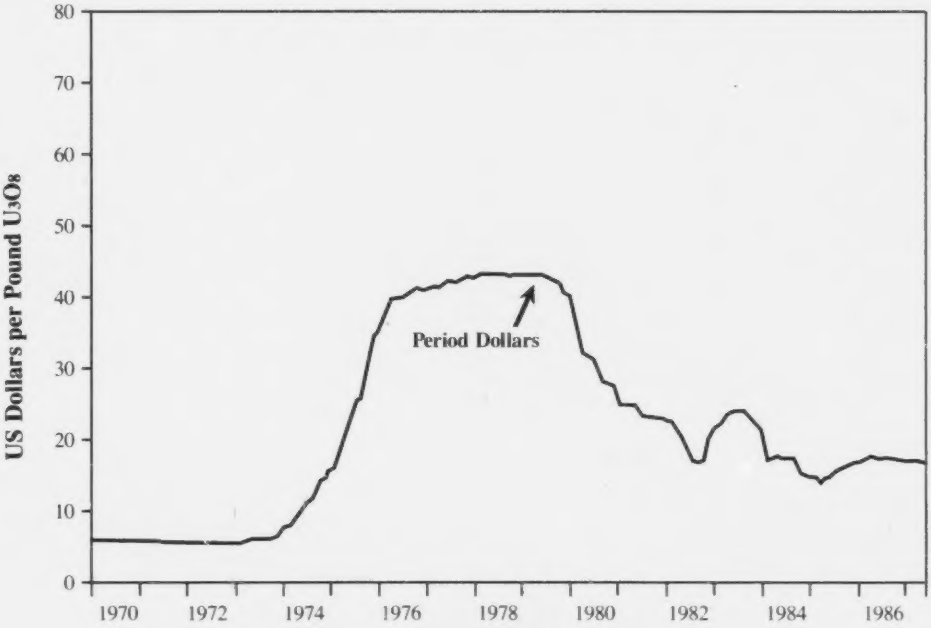


Figure 1
HISTORICAL NUEXCO EXCHANGE VALUE

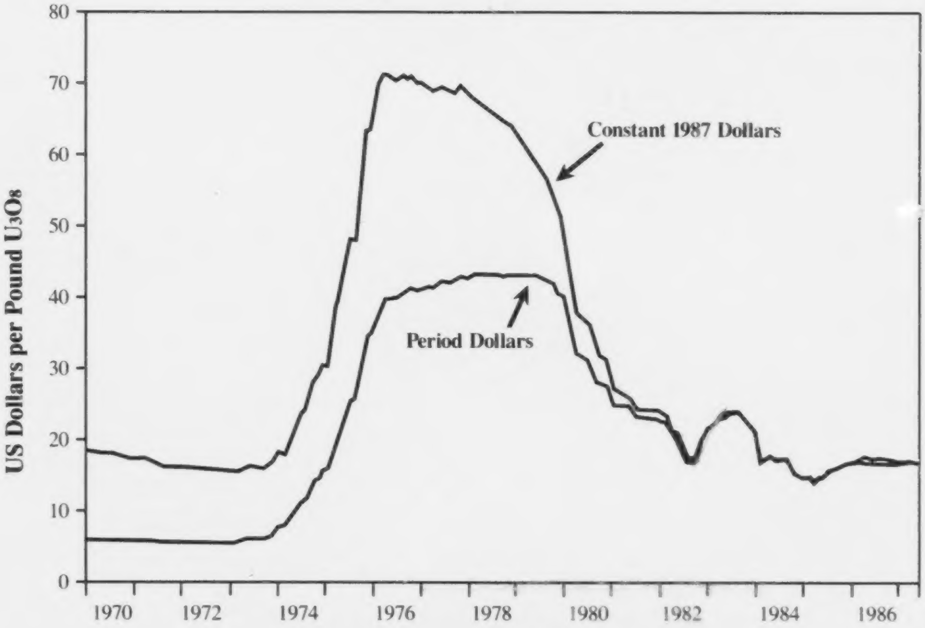


Figure 2
HISTORICAL NUEXCO EXCHANGE VALUE
(Period Dollars Versus Constant 1987 Dollars)

© NUEXCO 1987

The net result, regardless of which route or combination of routes is adopted, is that less tonnage will be under firm contract, not only in terms of absolute quantity but also as a percentage of total forward requirements. The operative word here is firm. Nominal tonnage is one thing; firm tonnage or bankable tonnage may be something quite different.

The previous discussion leads me to conclude that increasing quantities of uranium will be purchased in the spot and near-term markets. I must point out that this assertion is not supported by currently available historical data. That data suggests that the volume traded in the spot market is an inverse function of the trend of spot market prices. I am, however, making a leap of faith to propose that, while utility participation in the spot and near-term markets may fluctuate as a function of price or other temporary factors, participation will increase absolutely over time.

Despite the lack of current evidence, I believe that this argument has an almost irrefutable logic. I see two driving forces. First, spot market purchases are the ideal means for utilities to match uranium deliveries with actual needs. Second, pricing has increasingly become an issue with Public Utility Commissions in general and in prudency reviews in particular. Simply put, PUC's have but a limited capacity or willingness to learn the complexities and peculiarities of the uranium market. They can understand and have accepted published spot-market-price indicators, and have normally allowed such prices to be passed through to rate-payers. Paying the spot price will likely remain a defensible posture. On the other hand, prices above the spot level run the risk of closer scrutiny and possible disallowance.

My third point was that increased quantities of uranium would be delivered at spot market prices. If, in fact, more uranium is purchased in the spot market, such purchases will represent at least a portion of the increase in spot market-priced deliveries. In addition, however, I believe that spot market price indicators will increasingly be used as the primary price determinants in long-term contracts.

Figure 3 shows the amount of uranium delivered at spot market prices for the years 1983 through 1986. It also shows the amount of material that would have been delivered at such prices, but for the operation of floor price provisions. And it indicates that, in 1985 and 1986, about 40 percent of all uranium was delivered under contracts with spot market-related pricing provisions. While four years does not constitute a proof, the trend is evident and the absolute numbers are impressive. Further, we believe that the 1987 data will equal or exceed the 1986 figures.

While spot market pricing of long-term contracts has been primarily a US phenomenon, non-US buyers are showing increased interest in the approach, as a consequence both of the experience of US buyers and of dissatisfaction with the pricing arrangements of their own contracts. Neither a sudden nor a total change is anticipated, even in the USA, but as existing contracts expire and new long-term contracts or extensions are negotiated, we expect to see additional non-US buyers adopting spot market-related pricing provisions.

The development of these three trends will, in turn, lead to other commercial and financial changes. Consider the producers. Financing the development of uranium production operations has historically been a phased affair. Typically, equity capital is used to fund land acquisition, exploration and early development. Later, the larger costs of mine and mill construction are funded with debt which is secured by the facilities themselves and a portfolio of sales contracts that guarantee the purchase of the output at prices sufficient to service and repay the loans. The original financing of the Ranger project in Australia, which was well documented in its original prospectus, is a textbook example.

But if future long-term contracts are indeed characterized by extreme tonnage flexibility, and the pricing is market-based instead of firm, will similar financing be available for new projects? I doubt it. Furthermore, only the highest-grade producers have the operational capability to deal with a portfolio of contracts, all of which provide requirements-type flexibility, and even those high-grade producers could face difficult financing problems. Will utility buyers be sensitive to these producer predicaments and moderate their demands? I doubt it.

And consider the utility position. For utilities in general, and US utilities in particular, there is the public oversight issue, the need to deal with second-guessing and 20/20 hindsight, often with respect to actions taken years earlier in good faith and with the best information then available. The need to avoid being wrong often overrides the desirability of being smart.

In addition, nuclear fuel imposes an enormous financial burden on utilities. Where the nuclear fuel lease was once seen as the nirvana, we have seen that whatever the accountants give they can also take away. As you know, FASB statement No. 71 requires that off-the-balance-sheet financing be reflected on the balance sheet beginning in 1988. Increased utility debt, the downgrading of bond ratings, and the need to improve financial results generally suggest the need and opportunity for new initiatives.

And while buyers and sellers may develop close personal relationships, the realities of both the public utility and producer sectors, including recent efforts to enact protectionist

©NUEXCO 1987

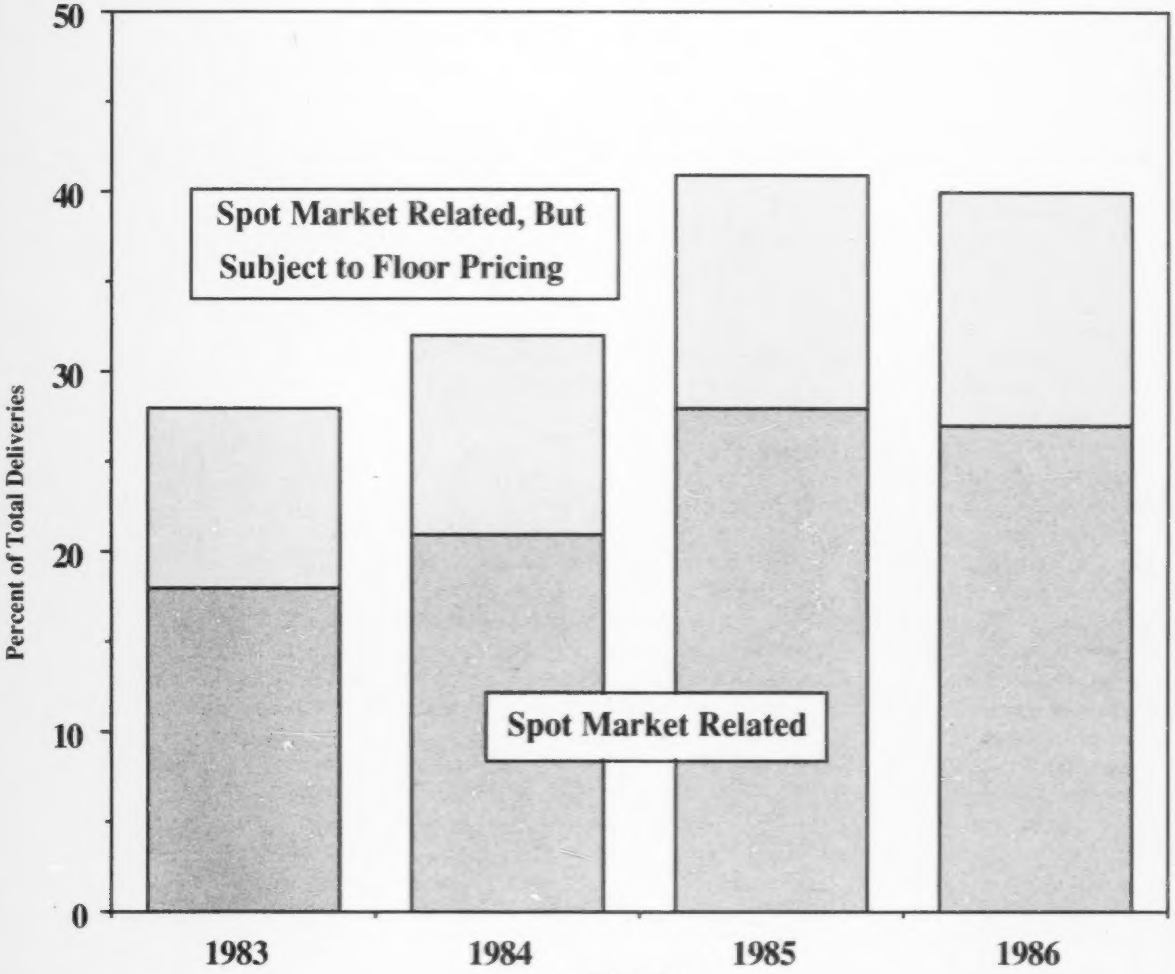


Figure 3

URANIUM DELIVERED UNDER SPOT MARKET-RELATED PRICING PROVISIONS

legislation, suggest the maintenance of, and possibly even an increase in, the traditional adversarial posture. Here, then, is the challenge for marketing and financial managers. But identifying problems and providing solutions are two entirely different matters.

The central issue is one of risk. Who is at risk? What sums are at risk? What is the duration of the risk? And the solutions to the problems identified above involve the shifting of risk from the existing players to new parties via new mechanisms. If sellers will not sell at market price, and buyers insist on market price, there is an opportunity for an intermediary to step in. That intermediary role could be assumed by existing uranium traders, or by equity investors.

Certainly, over the past several years the brokers and brokers/traders have increasingly involved themselves directly in transactions as principals. Such involvement often reflected relatively risk-free, so-called "back-to-back" deals, designed to mask identities and prices or to expedite complex or multi-party transactions. More recently, however, some of these organizations have become more aggressive, making commitments and accepting risk, sometimes considerable risk, with respect to mismatches in time, origin, delivery location, and form of uranium.

To my best knowledge, the uranium business does not yet boast big position leaders, such as are represented by Salomon Brothers and Goldman Sachs in the equity and debt markets. But that day could be coming. While most of the present brokers and broker/traders appear to lack the requisite capital resources to engage in such trading for their own account and risk, one can easily imagine a joint venture where the small uranium broker provides expertise and a commercial bank, insurance company, investment bank, or other large entity provides capital. The financial resources of such organizations would also provide the instant credibility that the smaller players would lack.

In addition to new and larger players, we anticipate new commercial and financial tools and techniques. There is no reason to believe that interest rate swaps, currency swaps and forward hedges and even price swaps cannot be used in the nuclear fuel market just as they are in oil and other commodities. While the utilities and producers are not typically staffed or inclined to do this sort of thing themselves, it is precisely this kind of expertise that can be expected of those entities involving themselves as intermediaries. This development does not constitute wishful thing. Albeit a modest beginning, a few substantial and sophisticated transactions have already been completed. More will follow.

Summary and Conclusion

I suggest that market trends are creating new situations in which it is increasingly difficult for utilities and producers to accommodate each others' requirements. The needs of one tend to impose unacceptable risks on the other. An opportunity has developed for financially strong and sophisticated entities to become involved in ways that will reduce risk for the principal parties. As with other commodities, these new associations will tend to supplant the traditional linkages between producers and users.

One final matter may have occurred to many of you. The original outline and initial draft of this paper were completed prior to the July 20, 1987 ruling by the 10th Circuit Court of Appeals in the lawsuit involving the US producers and DOE. The obvious questions is: could the basic positions advanced here be altered by judicial or legislative events? My answer is no. While the timing of the forecast trends may be accelerated or slowed by court or congressional actions, I anticipate that, even in a distinct multi–market environment, each will develop along the suggested lines.

©NUEXCO 1987

UNITED STATES

Recent Nuclear Industry Mergers

Within the last year, several major nuclear-industry companies have been involved in mergers or strategic affiliations that have the potential to substantially affect the US nuclear business. These alliances include Kraftwerk Union's (KWU) purchase of Exxon Nuclear Inc. in late 1986; a recent alliance between KWU and Bechtel Group Inc.; a joint venture agreement between a French consortium consisting of Framatome, Cogema Inc. and Uranium Pechiney with Babcock & Wilcox (B&W); and a proposed merger of Sweden's ASEA and BBC Brown Boveri of Switzerland.

With the possible exception of the ASEA-Brown Boveri merger, these alliances are aimed primarily at giving European firms a better entree into the US nuclear market, although improved presence in other markets could result as well.

During much of 1986, rumors persisted that KWU was interested in acquiring the nuclear fuel fabrication subsidiary of Exxon, Exxon Nuclear. A deal finally was approved by the Nuclear Regulatory Commission (NRC) in October 1986, in which KWU purchased a majority interest in Exxon Nuclear, which was renamed Advanced Nuclear Fuels (ANF) Corp. KWU's purchase arrangement included buying all of Exxon Nuclear's common stock, with Exxon Corp. keeping an option for some preferred stock for up to two years. In order to avoid any problems with access to classified US government information, Exxon Corp. has taken over Exxon Nuclear's former DOE contractor subsidiaries Exxon Nuclear Idaho Co. Inc. and Jersey Nuclear-Avco Isotopes Inc. ANF will continue to be headquartered in Bellevue, Washington and retains the former Exxon Nuclear subsidiaries in Brussels, Belgium and Lingen, FR Germany, the site of a manufacturing facility.

Exxon reportedly controlled approximately 15 percent of the US reload market, a figure that the new company is eager to expand. As ANF, the venture reportedly will share expertise with KWU, coordinating the companies' research and development activities and identifying areas for independent research work. Although KWU also manufactures nuclear fuels for BWRs and PWRs, US customs duties on import of fabricated fuel assemblies have inhibited KWU's efforts to penetrate the US reload market. ANF will also possibly manufacture and market KWU-based nuclear services technology in the USA, including fuel rod consolidation technology.

KWU also owns 60 percent of the KWU-Nukem joint venture fuel fabrication plant Reactor Brennelement Union (RBU), in Hanau. To complete the purchase of Exxon Nuclear, the venture had to gain the approval of German antitrust law authorities; by buying the Exxon plant in Lingen, KWU would be in a position to control over 80 percent of the German LWR fuel rod market. The approval reportedly was based on the strong competition from other European fuel fabricators, which would act to restrain prices.

In June 1986, Bechtel Group Inc. and KWU announced what they termed a "strategic alliance" to compete jointly in the US nuclear services market. The venture, which is expected to eventually form a new organization, reportedly will offer a broad range of services, including inspection and testing, supply, repair and replacement of equipment, outage planning, radioactive waste and processing management, decontamination and refueling. Bechtel currently has about 4,000 of its 9,000 nuclear division workers committed to service work on more than 40 operating plants.

The alliance gives KWU a much better position in the US services market, as well as possibly improving Bechtel's chances in the European market, where the US company has only a very small presence. Thus far, KWU has done a small amount of consulting and examination-testing work in the USA, but has not succeeded on a large scale in the US market. While KWU has considerable experience in nuclear steam supply systems (NSSS), having supplied 32 PWR and BWR plants on a turnkey basis, Bechtel has concentrated on architect/engineering and construction, and has been involved in building about 40 percent of the free world's reactors. KWU's affiliation with Advanced Nuclear Fuels and now Bechtel offers the possibility of integrated fuel supply and reactor service arrangements. This degree of integration potentially could compete head-on with Westinghouse in the USA.

Also looking to compete in the US nuclear fuel fabrication market, a consortium of three French companies — Framatome, Cogema Inc., and Uranium Pechiney — have signed a letter of intent with Babcock & Wilcox in which the French firms will buy a 49-percent share of B&W's

©NUEXCO 1987

commercial nuclear fuel services unit in the USA, including B&W's fuel manufacturing plant in Lynchburg, Virginia. Not included is B&W's separate fuel operation for the US Navy. The French firms intend to form a new US corporation for their part of the venture, in which Framatome and Cogema will each own 40-percent shares, and Uranium Pechiney will hold a 20-percent share.

The joint venture will be concerned primarily with marketing PWR nuclear fuel, and not with nuclear services, at least for the present. Under a 1981 agreement with Westinghouse, Framatome is excluded from marketing its standard PWR fuel in the US market; now, under the venture with B&W, it can participate in the US market, albeit indirectly. The French participation primarily is based on financial, rather than technological, involvement, although there is the potential for much increased access to several US nuclear market elements, such as reprocessing and nuclear waste management, where the French companies have considerable experience.

In August 1987, Sweden's ASEA and Switzerland's Brown Boveri BBC announced that, effective January 1, 1988, the two companies would merge their operations into one company, whose headquarters location has yet to be announced. Although the merger still must be approved by the Swedish and Swiss governments, company shareholders and labor unions, the new company, named ASEA Brown Boveri, will be the world's largest heavy electrical manufacturer, having annual sales of more than $15 billion. Although the merger is aimed mainly at increasing the companies' business in Western Europe, one of its objectives will be to increase its presence in the US market, where it currently is not well known.

Both ASEA and Brown Boveri have considerable involvement in the nuclear business. ASEA, through its subsidiary ASEA-Atom, is a turnkey supplier of nuclear plants, and also supplies fabricated nuclear fuel. In particular, ASEA-Atom has been increasing its share of the BWR control rod market, including contracts to supply hafnium-tipped control rods to several US plants. Brown Boveri's main nuclear-related business has been manufacture and repair services for turbine generators and related power equipment. Three BB turbine generators are to be installed at TVA's Bellefonte station. Brown Boveri also has been involved in rebuilding several Westinghouse turbines at Commonwealth Edison plants, and at Sacramento Municipal Utility District's Rancho Seco unit.

* * *

Seabrook Update

For the last two years, the Seabrook and Shoreham nuclear plants have been the center of a controversy involving the authority of the federal government to license plants for operation even where their operation and licensing is resisted by local communities or state governments. Seabrook Unit 1, whose largest ownership is held by New Hampshire Yankee, was built in New Hampshire but lies within two miles of the Massachusetts border. Its proximity to Massachusetts places several communities in that state within the 10 mile-radius emergency planning and evacuation zone. The Shoreham reactor, owned by Long Island Lighting Company (LILCO) of New York, was built on a part of Long Island whose roadways, say critics, do not provide sufficient capacity for an emergency evacuation of summertime crowds that use the area's popular beaches. In both cases, the plants are complete and ready to begin operation. At issue is whether state governments can block the licensing of a plant by the US Nuclear Regulatory Commission (NRC) by refusing to participate in the emergency evacuation exercises required for licensing.

Seabrook Unit 1, a 1,150-MWe Westinghouse PWR, is owned by 16 utility partners, with New Hampshire Yankee comprising 36.1 percent of the total ownership. The plant was scheduled to begin loading fuel in June 1986, with commercial operation on October 31, 1986. Although New Hampshire had approved the plant, three Massachusetts townships lie within the 10-mile radius emergency evacuation zone, and thus are affected by any emergency planning for the plant. Massachusetts Governor Michael Dukakis had early expressed his opposition to the plant's operation, but in the spring of 1986 he had offered a compromise that appeared to resolve the problem; if the plant would shut down during the peak summer months, he would not attempt to block its licensing.

Then, in April 1986, the accident at Chernobyl occurred. After that event, Dukakis withdrew his compromise offer and ordered a study of the plant's safety. At the time, Dukakis also was preparing for his November reelection bid for the governorship. Because the governor did not file the necessary emergency response plans with the Federal Emergency Management Agency (FEMA), and would not allow Massachusetts' participation in the emergency planning required for initial licensing of Seabrook, the NRC

©NUEXCO 1987

was forced to withhold the plant's license to load fuel, then scheduled for June 1986. (New Hampshire had already approved the evacuation plans.)

In August, Seabrook's owners requested that the NRC review a utility-sponsored study showing that the plant's technical features and especially strong containment structure allowed a reduction in the Emergency Planning Zone (EPZ) from a 10-mile radius to only one mile, with no greater danger to the public. If such a reduction could be approved, then Massachusetts would have no grounds for delaying operation of the plant. The owners estimated that the delay would cost approximately $50 million per month.

At the same time, Seabrook's owners also requested that the NRC grant the fuel-loading license, on the grounds that it would allow precriticality testing and evaluation, and since it did not provide for actual criticality, would not affect the emergency planning controversy in any way. In October 1986, the NRC approved the fuel-loading license for Seabrook.

In October and November 1986, Massachusetts challenged the fuel-loading license before the Atomic Safety and Licensing Appeal Board (ASLAB), on the grounds that all emergency planning matters must first be resolved before any licensing can proceed. In November, the ASLAB found that zero-power and low-power licenses did not require such a resolution.

In December, Seabrook's owners again asked the NRC to limit the required evacuation zone to a one-mile radius. Then, in January 1987, the NRC commissioners voted 4-1 to review the ASLAB decision, ordering the NRC staff not to issue a low-power license. By June 1987, FEMA had issued a report critical of the plant's evacuation plans, but stated that such a finding was not to be considered binding on the NRC in issuing operating licenses. Meanwhile, ASLAB had denied the Seabrook owners' request to have the EPZ reduced to a one-mile radius.

Also in June, Rep. Ed Markey (D-Massachusetts) sponsored an amendment in the House Energy and Commerce Committee that would prohibit the NRC from issuing full-power licenses to any plant not operating as of January 1, 1987, unless all states within a 10-mile radius of the plant, FEMA, and the NRC all agreed that the evacuation plans were adequate. Such a proposal would effectively have given the 10-mile radius the status of a law, which it does not now have. Markey's amendment was defeated in a tie vote.

In August, however, the bill was attached to a compromise bill (H.R. 3037) authorizing funding of the NRC for fiscal years 1988 and 1989. After debate on the House floor, Markey's amendment was again defeated, this time by 261-160. While Markey and his supporters portrayed the alleged dangers posed by the plants as a local issue, nuclear industry supporters and lobbyists effectively turned the debate into an issue with national consequences. For the present, Congress appears to have conclusively supported federal regulatory control of nuclear plants, denying states' veto power over licensing decisions.

Following the Congressional debate, Seabrook's owners asked the NRC to lift its January stay on issuing a low-power license, and filed with the NRC an emergency plan covering six affected Massachusetts towns. The utility makes clear that the emergency plan was prepared to include even a complete lack of cooperation on the part of the Massachusetts state government. If a low-power license is granted, testing at up to 5-percent power could commence before the end of the year, with the plant possibly entering commercial service in mid-1988.

© NUEXCO 1987

THE US URANIUM INDUSTRY IN 1986 — IMPLICATIONS FOR VIABILITY

Introduction

At the US Council on Energy Awareness' 1987 uranium seminar in Keystone in September 1987, representatives of the US Energy Information Administration (EIA) presented statistics on the US uranium industry's activities during 1986 and the first half of 1987. Howard Walton (recently appointed Director of EIA's Nuclear and Alternate Fuels Division) presented statistics on the industry's operations and financial performance, and William Liggett outlined US uranium marketing activities. This article summarizes these presentations, presents comparisons with previous years' activities, and gives Nuexco's interpretation of significant developments indicated by this information. The statistics and analyses derived from them will be the basis of EIA's annual report on the uranium industry's viability, prepared to assist the Secretary of Energy in his annual viability determination. In addition, an exhaustive statistical report on the 1986 US uranium industry and US uranium supply, demand, marketing, and price is scheduled for release on October 23.

Production

The US uranium industry produced 13.5 million pounds of U_3O_8 in 1986, a 2.2 million pound increase over that produced in 1985. It may not be evident from the aggregate EIA statistics that, without the increased production of one company (Energy Fuels Nuclear, Inc.), the industry's production would have declined to about 9 million pounds U_3O_8. Figure 4 shows US concentrate production by state from 1979 through 1986. This figure clearly shows the rapid decline of uranium production in the old-line uranium mining states of New Mexico and Wyoming. In 1980, the year of the US industry's peak production of 43.7 million pounds, these two states accounted for 35 percent and 28 percent of US production, respectively. In 1986, they jointly accounted for only 10 percent of total production. The "Other" category encompasses primarily Colorado, Florida, Louisiana, Utah and Washington. Utah was especially important in 1986, as the site of the mill used by Energy Fuels.

Production from unconventional sources (primarily in situ leach and marine phosphate by-product recovery) has remained fairly steady in absolute terms over the 1980-1986 period, whereas production by conventional (underground and open-pit) mining techniques peaked at 37.8 million pounds U_3O_8 in 1980, declined to 6.1 million pounds in 1985, and increased to about 8.9 million pounds in 1986 (Figure 5). Again, without the contribution of Energy Fuels' production from underground mines in the Arizona strip, conventional production would have been only about 4.4 million pounds U_3O_8 in 1986.

One of the more interesting features of recent US production is the trend in ore grade. The average grade of ore processed in conventional mills was approximately 0.12 percent U_3O_8 during the 1979-1984 period, increased to 0.16 percent in 1985, and rose to over 0.33 percent during 1986. This reflects the phasing-out of production from relatively lower-grade ores in open-pit mining, the "high-grading" of remaining underground deposits, and the dominance of high-grade ores from new underground mines of Energy Fuels and of Chevron Resources' Mt. Taylor deposit. For Energy Fuels, the ore is mined in Arizona, but shipped to Utah for milling. For Chevron, ore is mined in New Mexico and shipped to Texas for milling.

Inventories

One of the major factors responsible for the downturn in the uranium market price was the large excess of production over nuclear power generation requirements. In fact, until fairly recent times, annual production from US sources was about twice the annual consumption by the utility industry. This led to the buildup of large uranium inventories, which have only recently begun to decline (Figure 6). Inventories held by suppliers remained steady over the 1984-1986 period, and the modest decline in total inventories during this period has been due to a decline in the US utilities' share.

The inventory data collected by EIA's Uranium Industry Annual Survey include all chemical and physical forms of uranium that have not been irradiated in a nuclear power plant. Figure 7 shows the breakdown of US utility year-end inventories in the 1983-1986 period. The utility industry's inventory of uranium in fabricated fuel assemblies remained steady during the 1984-1986 period, whereas the inventory near the enrichment stage (as uranium at enrichers for processing, in "usage agreement" accounts at the US Department of Energy's [DOE] enrichment complex, or enriched UF_6) increased steadily over the 1983-1985 period.

None of the increase from 1983 to 1986 was due to

© NUEXCO 1987

ANALYSIS AND COMMENTARY

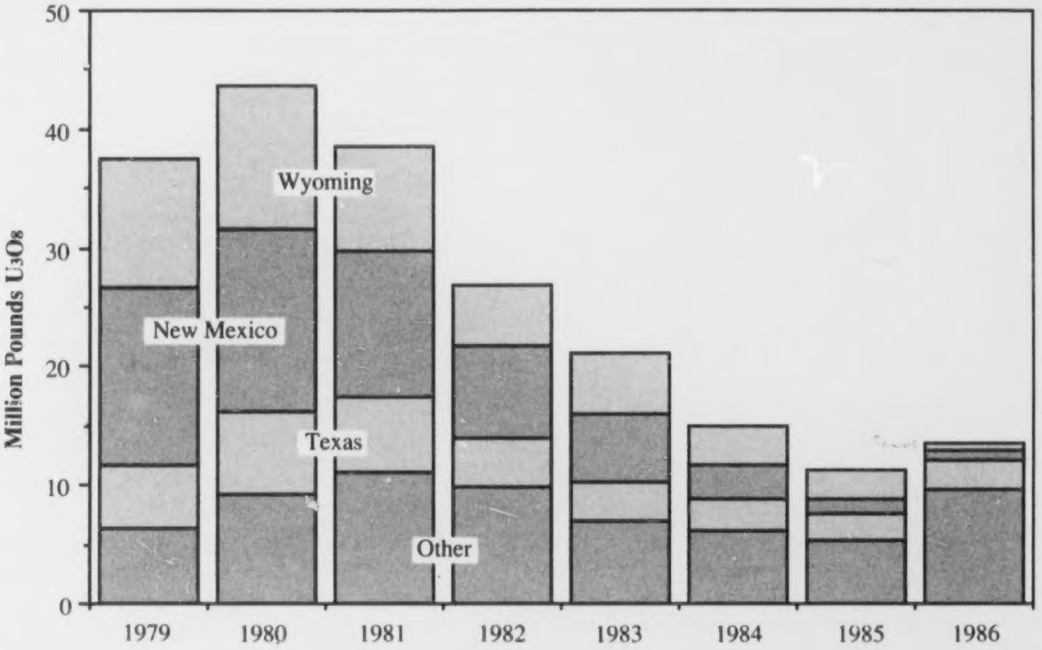


Figure 4
US PRODUCTION BY STATE

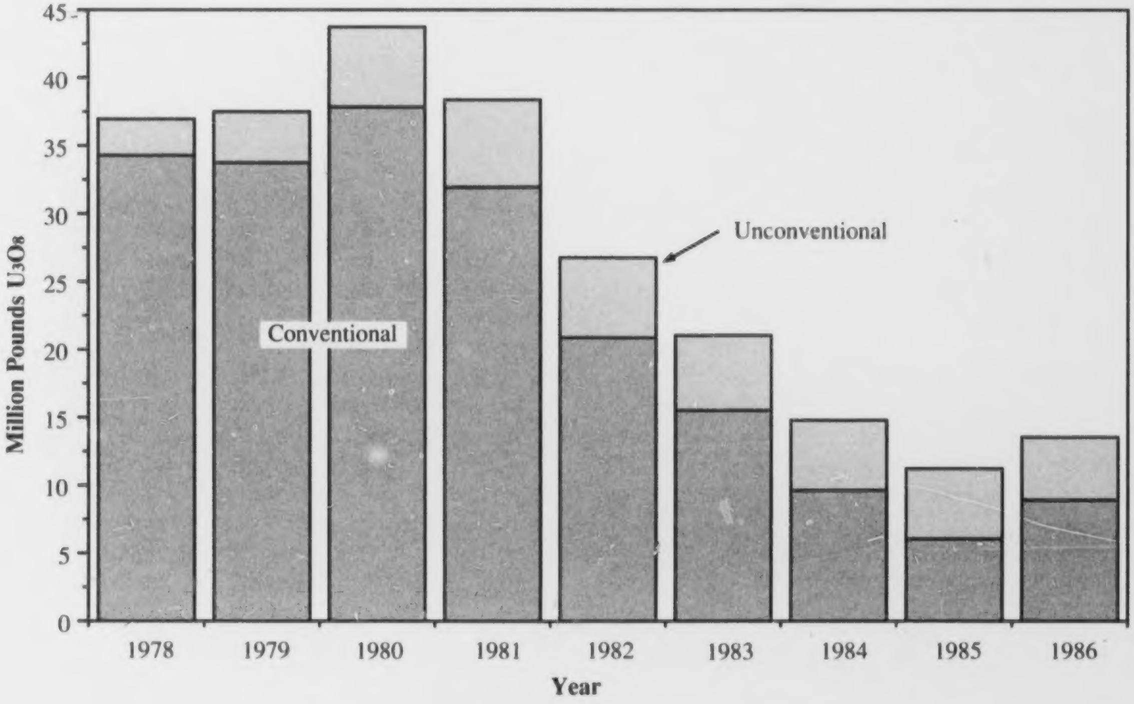


Figure 5
US PRODUCTION BY METHOD

© NUEXCO 1987

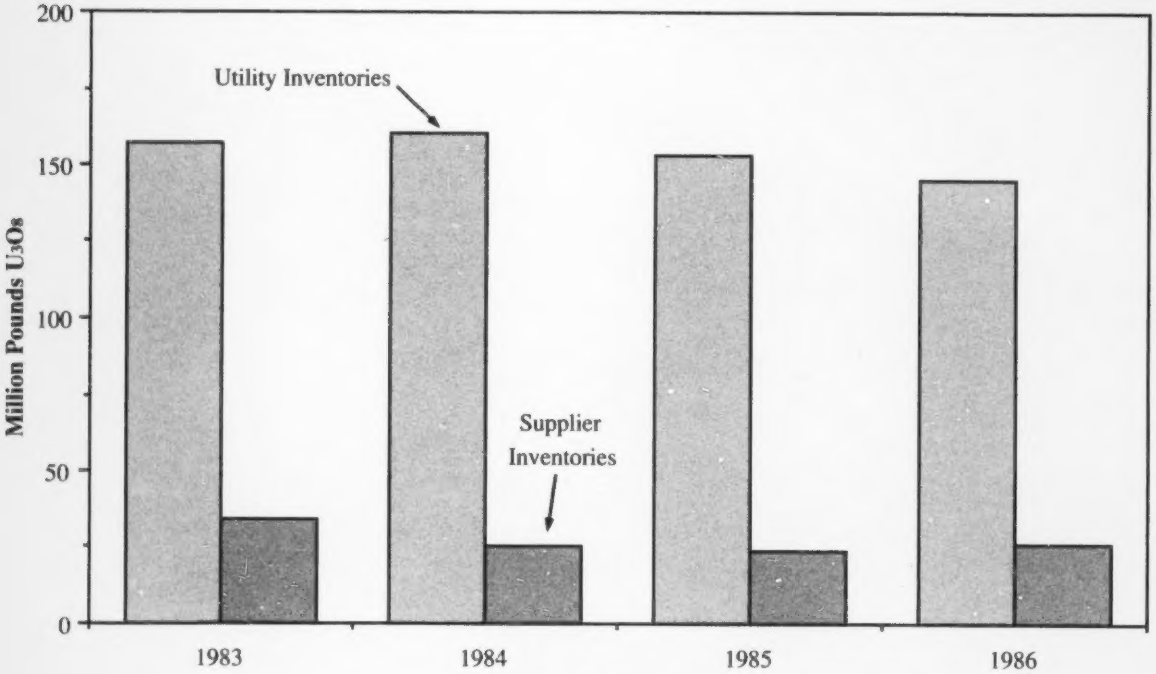


Figure 6
US COMMERCIAL URANIUM INVENTORIES

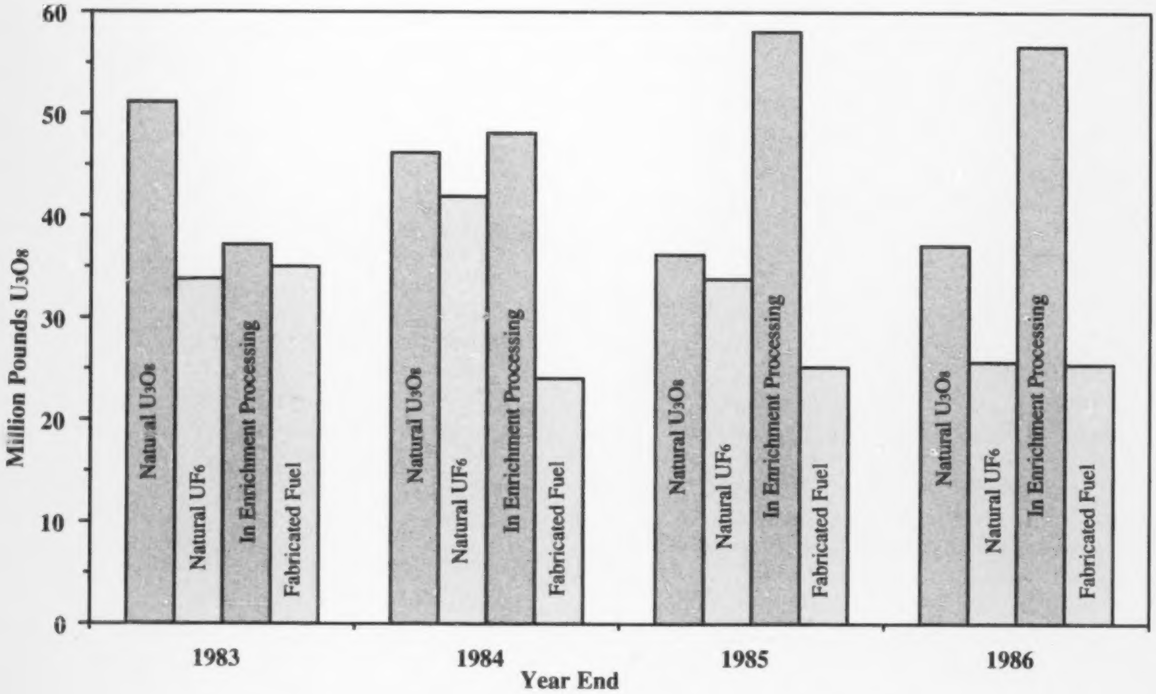


Figure 7
US UTILITY INVENTORIES

© NUEXCO 1987

enriched UF_6 in the utilities' possession; it was all due to increases in the other categories. As material moved into the enrichment stage, the inventory of natural uranium, as both U_3O_8 and UF_6, decreased.

The slight increase in natural uranium inventory during 1986 is perhaps due to the retention of US-origin material in anticipation of future restrictions on the use or enrichment of non-US-origin uranium and early delivery of South African import commitments (described below).

Uranium Contracting

According to EIA's statistics, the rate of new contracting for uranium supplies increased during 1986 to its highest level since 1982 (Figure 8). Over the five and one-half years ending June 30, 1987, imports accounted for about 60 percent of the quantity of uranium newly contracted for by US companies. Conversely, when contract cancellations and quantity adjustments each year are taken into account (Figure 9), there were net decreases in the quantity under contract to US suppliers for the 1984-1986 period, in contrast to net increases in each of these years for import commitments.

Figure 10 shows the net effect of all these new contracts and contract adjustments. The overall level and pattern of forward commitments between the ends of 1983 and 1986 are more or less unchanged. That is, the US utility industry has maintained a nearly constant level of forward commitments, by year, rather than increasing as would normally be expected. Thus, the overall level of commitments from new contracts has been almost offset by downward adjustments in old contracts.

This same feature holds for unfilled requirements (Figure 11). Unfilled requirements are defined by EIA as the amount of uranium the utility industry needs, over and above its current inventory and uranium purchase contracts, to meet projected uranium enrichment feed deliveries and to maintain a "desired" level of inventory. The major adjustments to unfilled requirements over the past 4 years have been reductions in the very near term. Of course, the level of unfilled requirements increases for more distant delivery years because utilities are less concerned about having more distant (and thus less certain) requirements under contract. This does not necessarily mean that each individual utility's forward commitments and unfilled requirements have remained constant over the period, but that the aggregate values have changed very little. All this points to more recent predictability for market requirements than in the past.

One parameter of constant interest in the USA is the structure of imports and import commitments. Figure 12 shows actual imports into the USA by country of origin. Imports in 1983 totaled 8.2 million pounds U_3O_8, of which 66 percent was Canadian origin, 24 percent was South African, and the balance was from various other sources. In 1986, US imports were 13.5 million pounds U_3O_8, of which 59 percent was Canadian and 41 percent was from other countries. To protect the confidentiality of the small number of firms involved in the South African imports, these imports were lumped into the "Other" category for 1986. However, a trend of increasing reliance on South Africa as a source of uranium seems apparent from this time series. It is likely that the level of US imports from South Africa will be drastically lower in 1987, due to the implementation of the US Comprehensive Anti-Apartheid Act of 1986, which prohibits the importation of South African ore or oxide.

In contrast to the increasing levels of actual imports from South Africa, reliance on South Africa for longer-term commitments seems to have tapered off in recent years. Even though South Africa is lumped into the "Other" category for 1986 forward commitments, the downward trend is clear from the data shown in Figure 13. There is a simple explanation for this apparent anomaly with South African imports. In fact, the total (past plus present) level of commitments for South African imports has not changed drastically in recent years, but the importers have taken early delivery in order to avoid the Anti-Apartheid Act restrictions that began in 1987. Finally, although Canada is the preferred country for US import commitments, the rapid increase in the absolute and percentage reliance on contracts with Australian suppliers for forward commitments is quite noticeable.

One significant development during 1986 was the sharp reduction in the level of uncommitted uranium available for sale by US suppliers, principally in the higher price categories (Figure 14). It seems evident that US producers with costs at or above $30 per pound U_3O_8 view themselves as being unable to compete with the lower cost producers over the next ten years. This view is generally consistent with most industry expectations of the price for a free market in uranium worldwide. However, an effective import restriction in the US could dramatically alter that outlook.

When compared to current unfilled requirements of US

© NUEXCO 1987

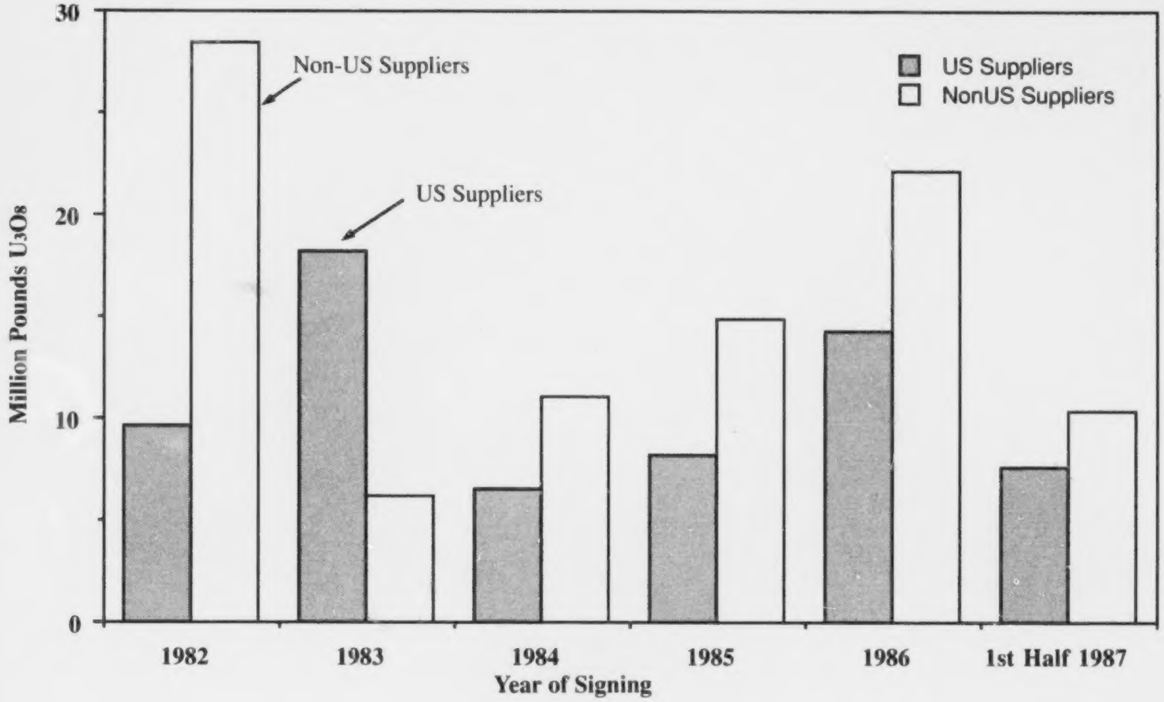


Figure 8
NEW CONTRACTS

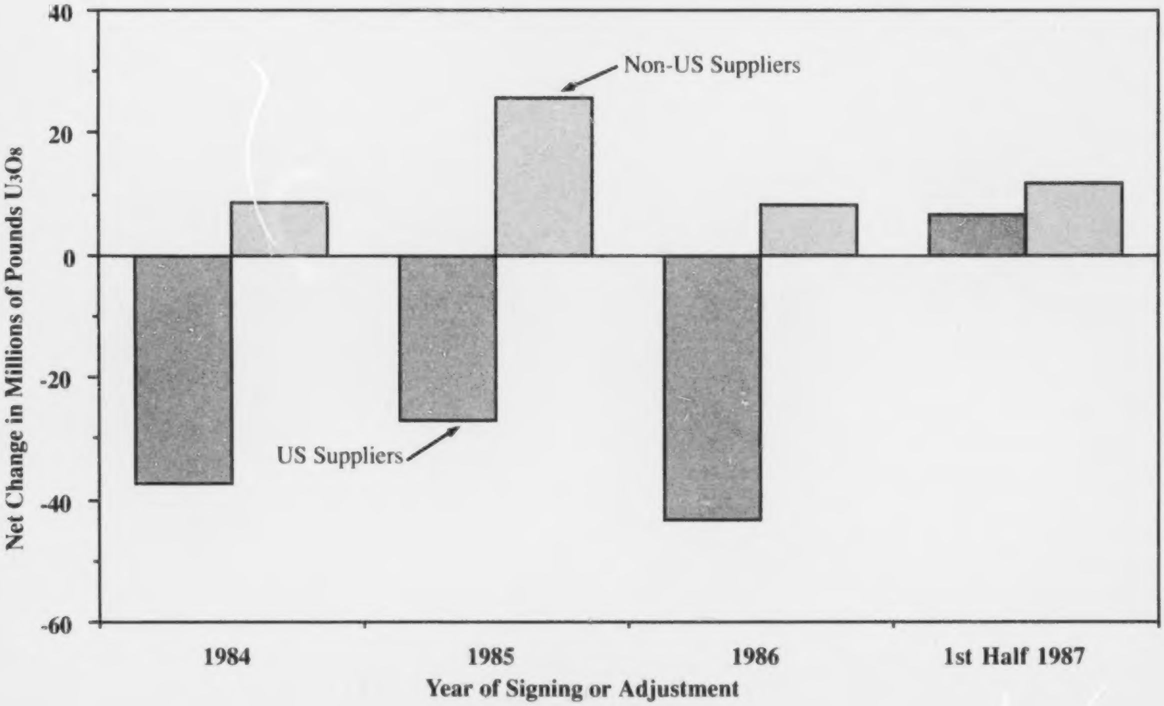


Figure 9
NET CHANGE IN CONTRACTS

ANALYSIS AND COMMENTARY

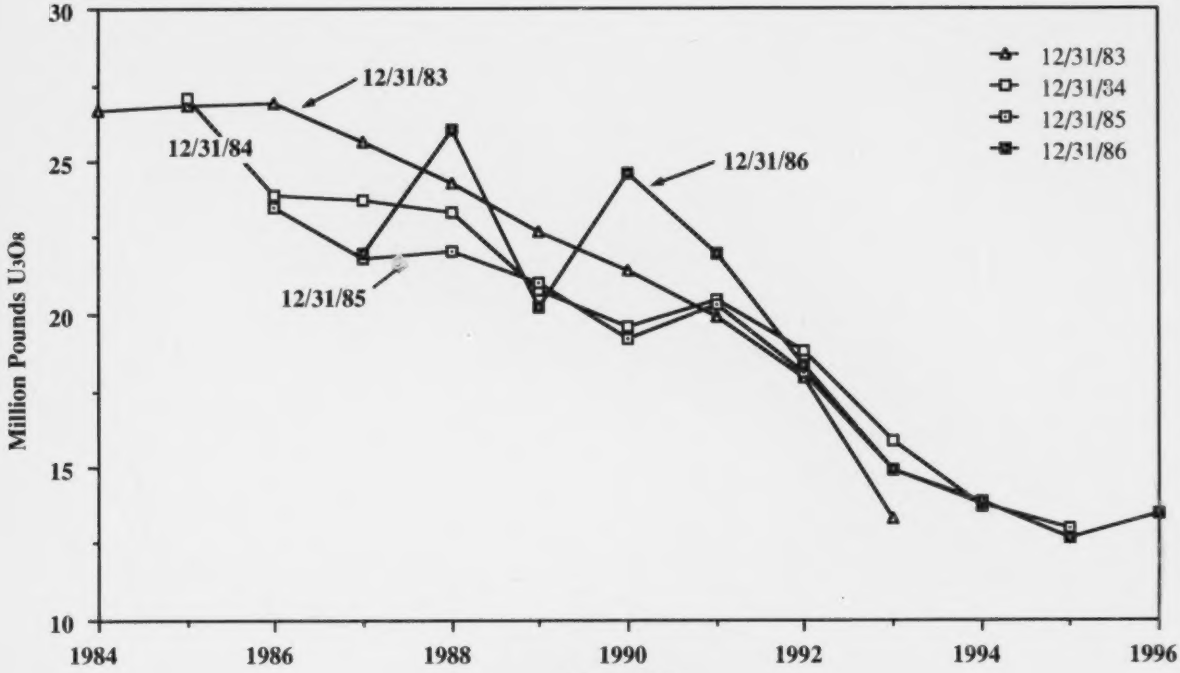


Figure 10
COMMITMENTS OF US UTILITIES

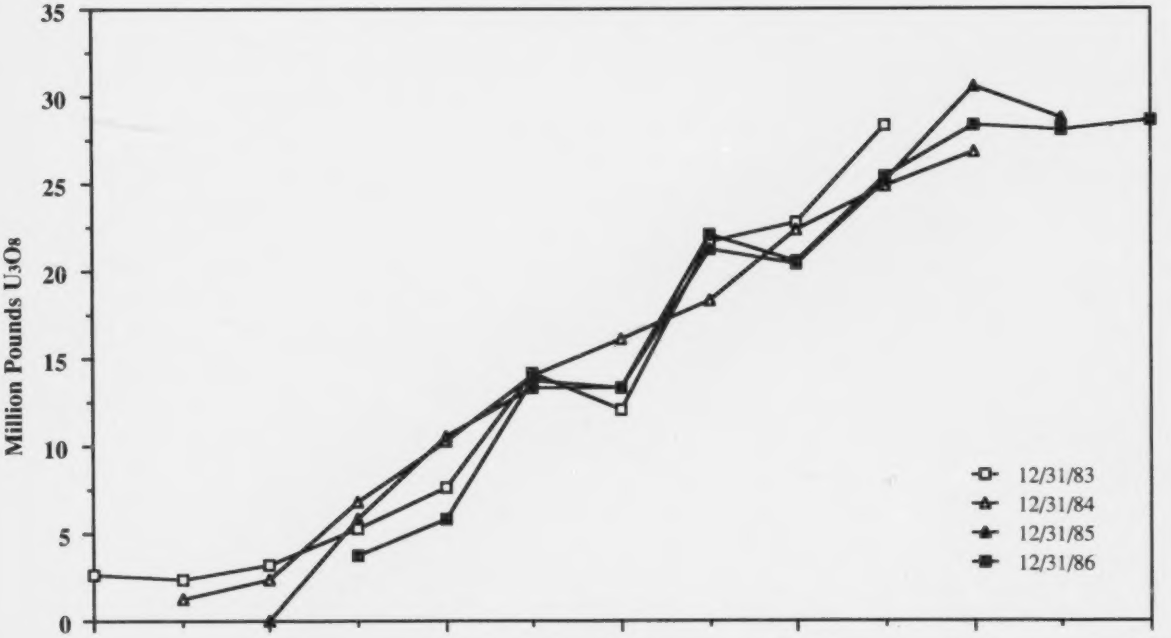


Figure 11
US UTILITY UNFILLED REQUIREMENTS

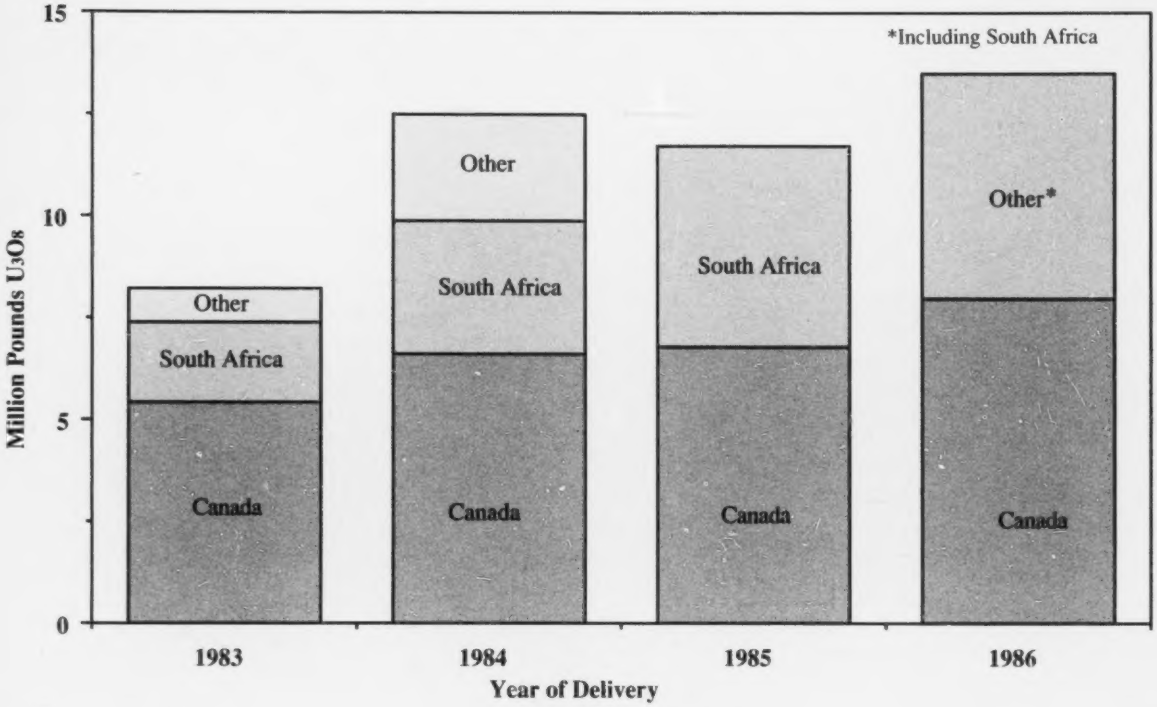


Figure 12
PAST US IMPORT DELIVERIES

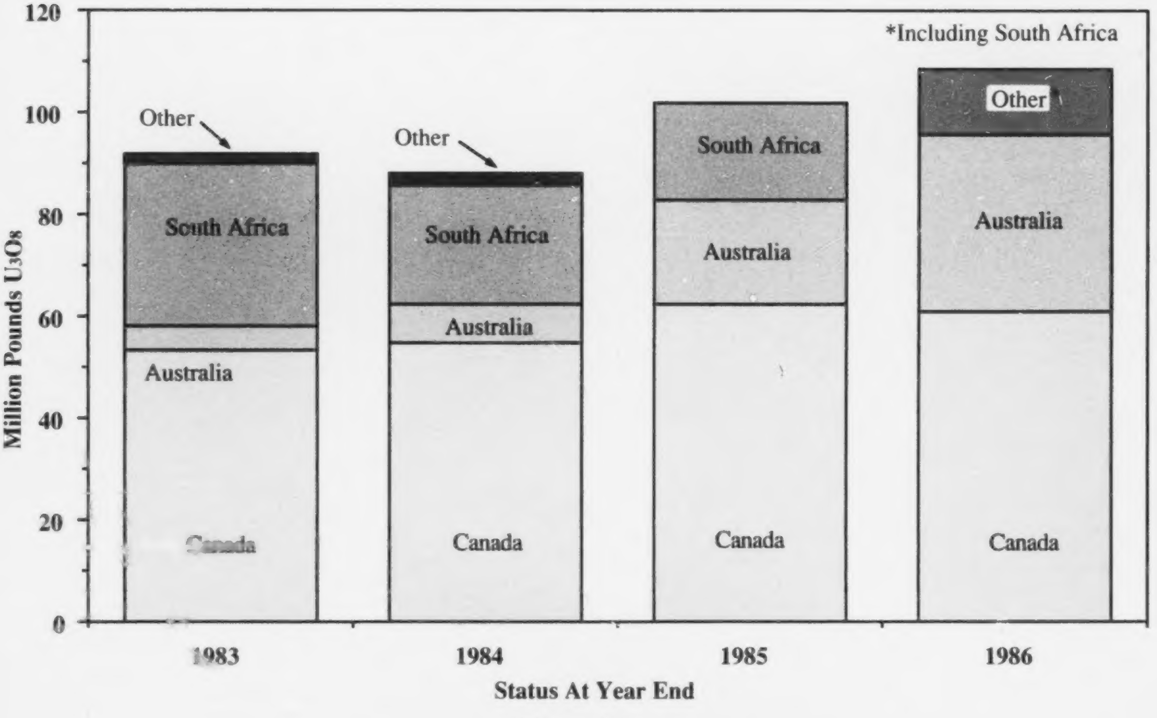


Figure 13
US IMPORT CONTRACTS FOR FUTURE DELIVERY

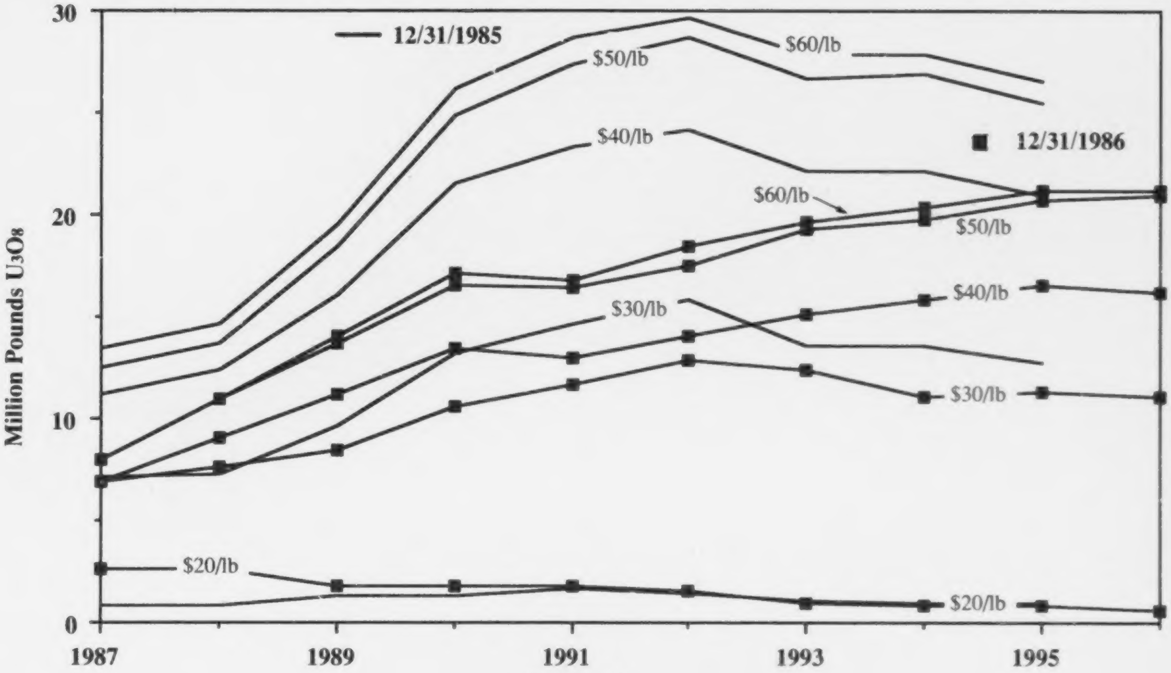


Figure 14
UNCOMMITTED US URANIUM AVAILABLE FOR SALE
(1985 vs. 1986)

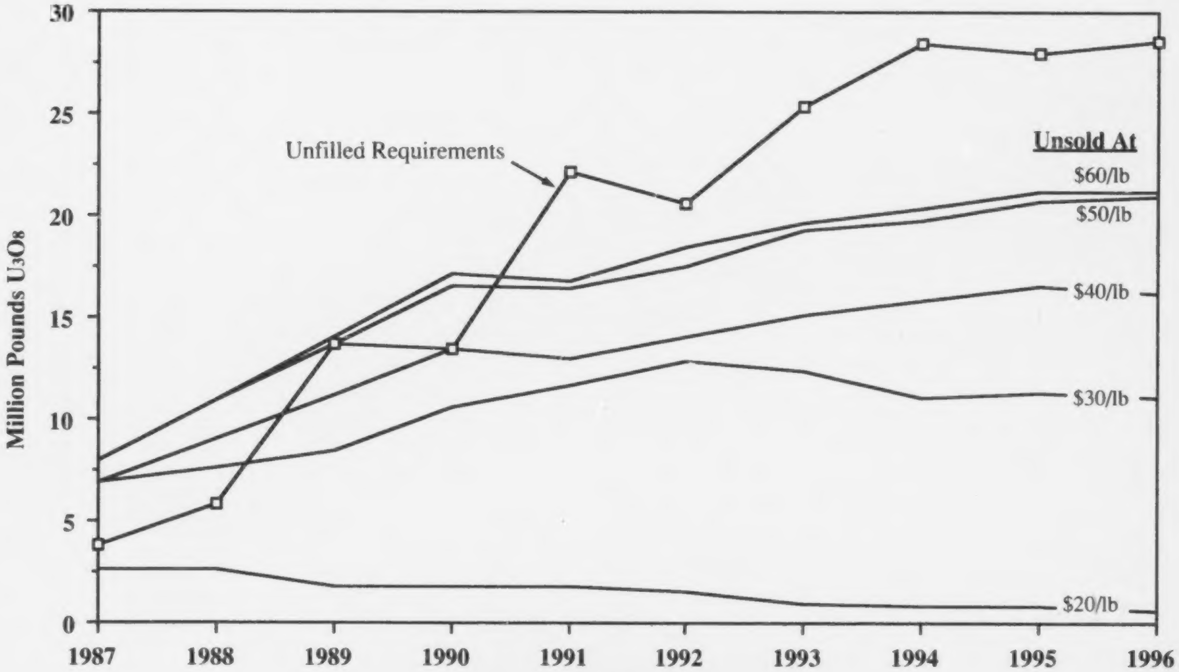


Figure 15
YEAR-END 1986 UNFILLED REQUIREMENTS
vs. URANIUM AVAILABLE FOR SALE

utilities (Figure 15), the uncommitted uranium reported as available for sale by US companies would not be sufficient to supply US needs on an annual basis beyond about 1990, even at price levels (in constant end-of year 1986 dollars) of $60 per pound U_3O_8. This is in clear contrast to the situation one year earlier, when uncommitted uranium available for sale would easily have been sufficient to meet US unfilled requirements. (Nuexco's opinion is that much more uranium could be made available than is reported here, if the market price rose to $60 per pound and stayed there for a prolonged period.)

The secondary market for natural uranium in the USA was healthy in 1986, as shown in Figure 16. The bulk of secondary market activity (10.3 million pounds of U_3O_8) represented sales and exchanges among US suppliers, followed by 7.2 million pounds of supplier imports.

Implications for the 1986 Viability Determination

By law, the Secretary of Energy determines the US uranium industry's viability, on the basis of information developed and reported by the EIA each year. In his deliberations, the Secretary considers four basic criteria, established in a 1983 public rulemaking.

1. Resource Capability: whether US economic reserves are sufficient to supply US needs over a projected ten-year period.
2. Supply-Response Capability: whether US uranium production capacity is sufficient to supply US needs over a ten-year period.
3. Financial Capability: whether the US uranium industry's financial performance will permit the maintenance of an adequate supply-response capability.
4. Import Commitment Dependency: whether uranium import contracts constitute more than 37.5 percent of US requirements for any two-consecutive-year period.

For the first three of these criteria, US "needs" are defined as the requirement for US production in the event of a disruption of uranium import supplies — so-called "uranium supply security requirements." The Secretary has historically focused on an assumed one-third disruption of contracted imports at a point in time, with the additional condition that no further import contracts would be signed. EIA has generally developed the requisite information on these criteria by assuming a hypothetical "current" disruption on January 1 of the year following the year in which the determination decision is being made, and a "projected" disruption at some more distant date. For the viability determination being made this year, involving the uranium industry's viability status for the year 1986, the current disruption would occur on January 1, 1988. The year of the more distant "projected" disruption is usually chosen to be a date at which dependence on imports is expected to be the greatest and beyond which excess inventory levels are expected to be small. The industry's viability status for the year 1985 assumed a "projected" disruption on January 1, 1991.

Although it is not possible to foresee what conditions EIA will assume and analyze for the projected disruption status, the data provided in the two EIA presentations can be used to estimate the "current disruption" status of the criteria. The following represents Nuexco's analysis of the data relevant to these criteria.

Resource Capability

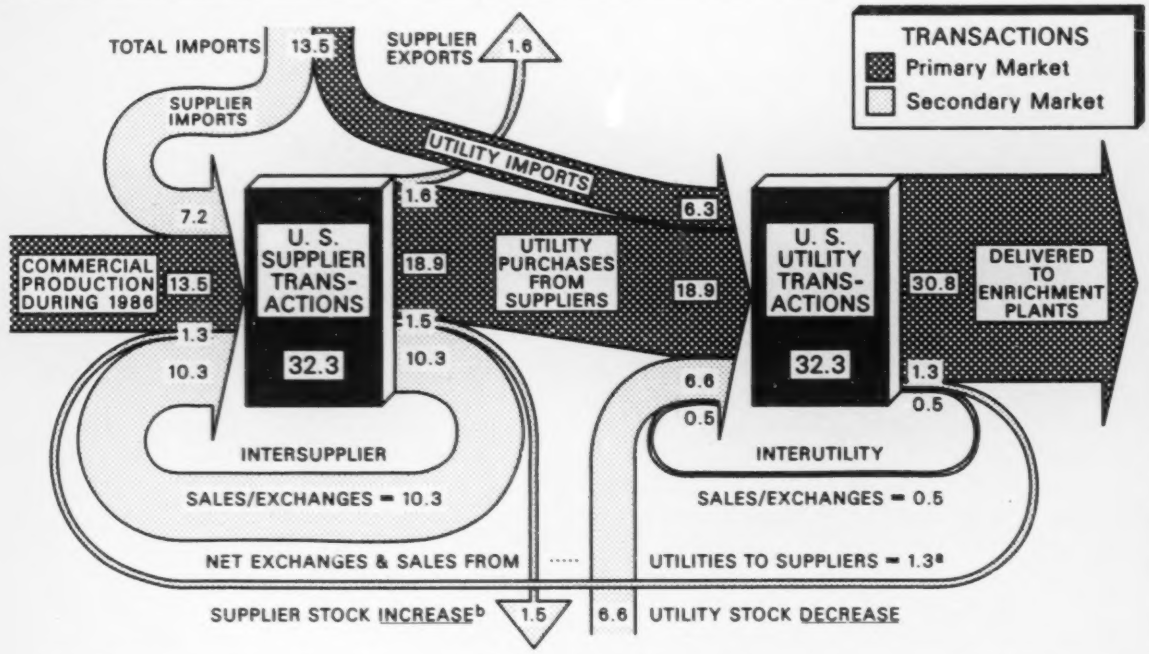
Traditionally, this criterion has not been the subject of much concern in the viability determination, because "economic reserves" as measured by EIA have always exceeded the US utility industry's needs under the one-third (and usually even the two-thirds and total import) disruption scenario. Although EIA collects economic reserves data directly from the uranium industry, such data are not used as the basis for this criterion in EIA's analysis. This is primarily because the legal language concerning this criterion specifies not whether economic reserves exceed needs, but rather whether domestic economic reserves can *supply* all future needs for a future ten-year period. Thus, EIA has preferred to use the US uranium industry's contracts for future delivery and uncommitted available for sale, both cumulated over the period in question, as the measure of supply from economic resources.

Using the committed and uncommitted data shown above (with accounting for the small level of export commitments), Nuexco's estimate of the current status of Resource Capability is shown in Figure 17. In contrast to previous years, economic reserves (as defined in previous EIA viability reports) do not appear to be producible to meet US uranium requirements in the event of a one-third disruption of US import supplies. Even the reported economic reserves (i.e., reported by the US uranium industry to EIA) only marginally equal ten-year forward US needs in the event of a one-third import disruption.

Supply - Response Capability

In the past two determinations of nonviability, supply

©NUEXCO 1987


TRANSACTIONS
▨ Primary Market
☐ Secondary Market
TOTAL IMPORTS
13.5
SUPPLIER EXPORTS
1.6
SUPPLIER IMPORTS
UTILITY IMPORTS
7.2
1.6
6.3
COMMERCIAL PRODUCTION DURING 1986
13.5
U. S. SUPPLIER TRANS-ACTIONS
32.3
18.9
UTILITY PURCHASES FROM SUPPLIERS
18.9
U. S. UTILITY TRANS-ACTIONS
32.3
30.8
DELIVERED TO ENRICHMENT PLANTS
1.3
10.3
1.5
10.3
6.6
0.5
1.3
0.5
INTERSUPPLIER
SALES/EXCHANGES = 10.3
INTERUTILITY
SALES/EXCHANGES = 0.5
NET EXCHANGES & SALES FROM ..... UTILITIES TO SUPPLIERS = 1.3ᵃ
SUPPLIER STOCK INCREASEᵇ
1.5
6.6
UTILITY STOCK DECREASE

[a] Excludes 1.4 million pounds that were delivered to enrichment plants in exchange with suppliers.

Source: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey", 1986.

Figure 16
NATURAL URANIUM MARKET ACTIVITY
DURING 1986

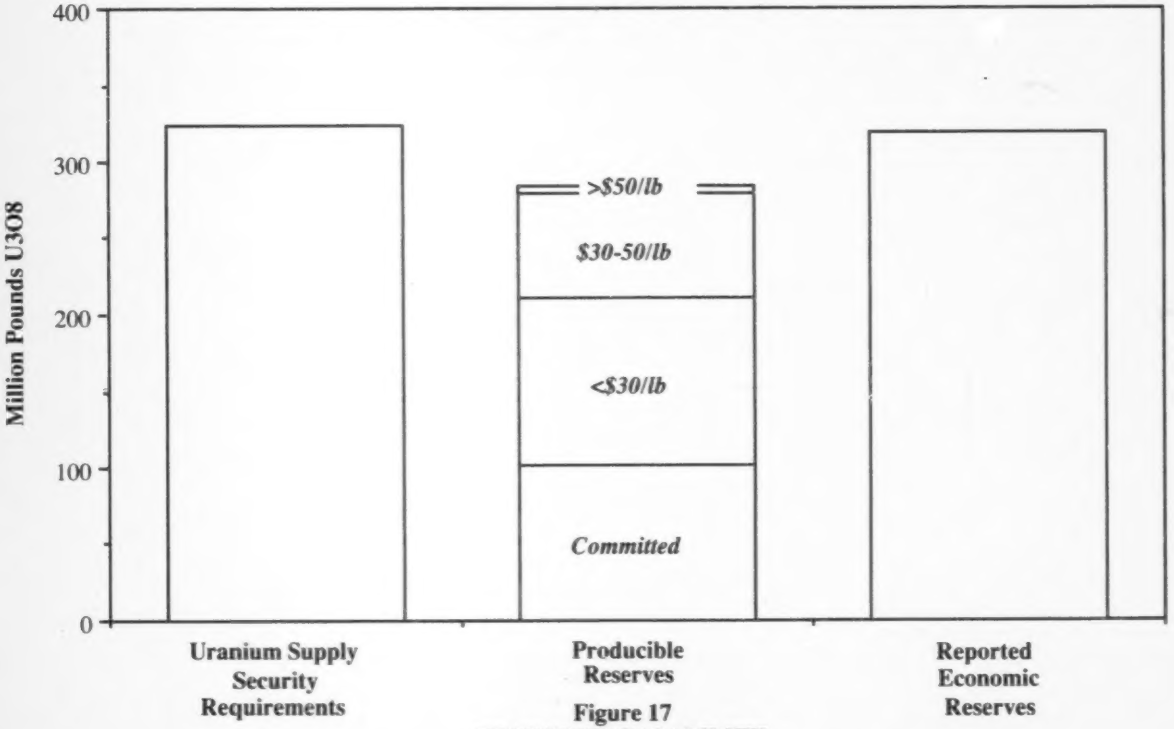


Figure 17
RESOURCE CAPABILITY

response capability for a potential future import disruption has been a major concern. Under EIA's projections, the US industry would not have had the ability to meet US needs over a ten-year import disruption beginning in 1991. On the other hand, this concern was always couched in terms of a concern about potential future conditions, because for each of these determinations the supply response capability for a "current disruption" had always been adequate.

The situation changed during 1986, as shown in Figure 18. Because of the reduction in both domestic uranium industry commitments and uncommitted uranium available for sale, the US uranium industry appears to be no longer capable of supplying US needs in the event of a ten-year-long, one-third disruption of import supplies. If the Secretary of Energy was concerned in the past about the potential development of this condition, it is now clear that the concern was justified. Fortunately, the concern is primarily for the latter half of such a disruption, as the uranium industry appears to be able to supply needs over the first five years of the disruption period.

Financial Capability

A major factor in Secretary of Energy Herrington's determination that the US uranium industry was not viable for the years 1984 and 1985 was the industry's dismal financial performance in those years. As seen in Figure 19, the industry's operating and net income improved for the industry as a whole, compared to 1984 and 1985, but only in the sense that the industry's losses were smaller. Operating income is the excess of gross revenues from U_3O_8 sales over direct operating expenses, whereas net income reflects the further effects of financing (interest) expenses, income taxes, and extraordinary items, such as the massive writedowns or writeoffs in the value of uranium property, physical plant and equipment (PP&E) that occurred in 1984 and 1985. These one-time writedowns and writeoffs reflected the recognition by some firms that recovery of their investment in these uranium facilities would not occur in the foreseeable future because of the expected persistence of poor market conditions for the producing industry.

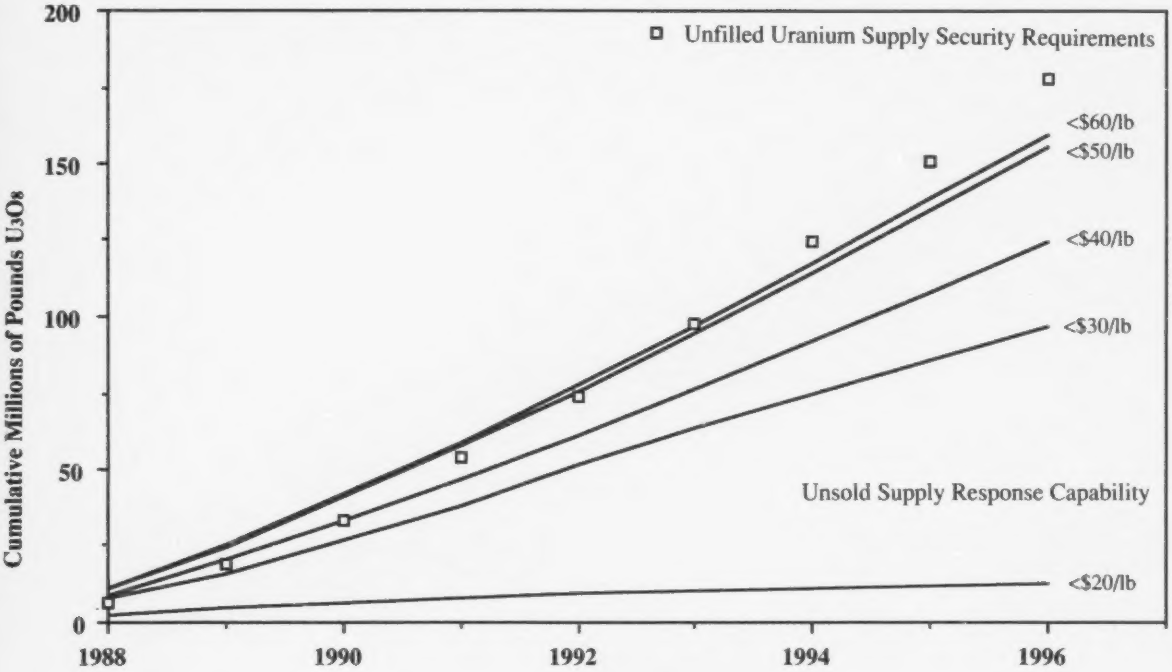


Figure 18
SUPPLY—RESPONSE CAPABILITY

©NUEXCO 1987

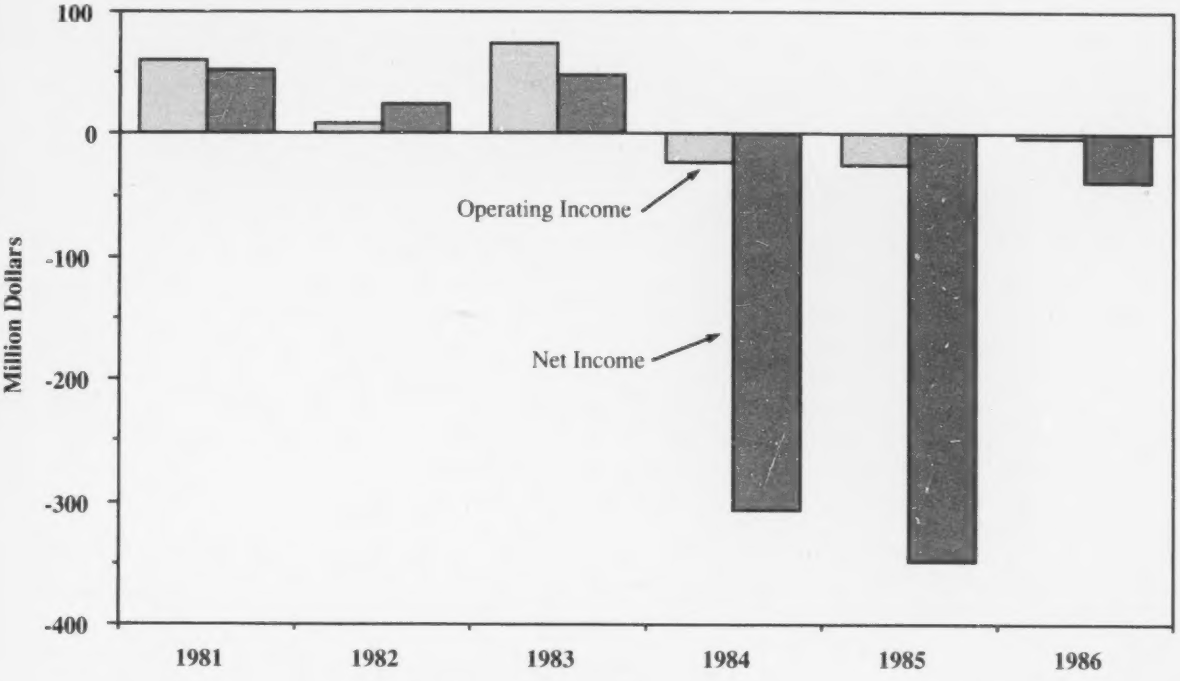


Figure 19
US URANIUM INDUSTRY INCOME

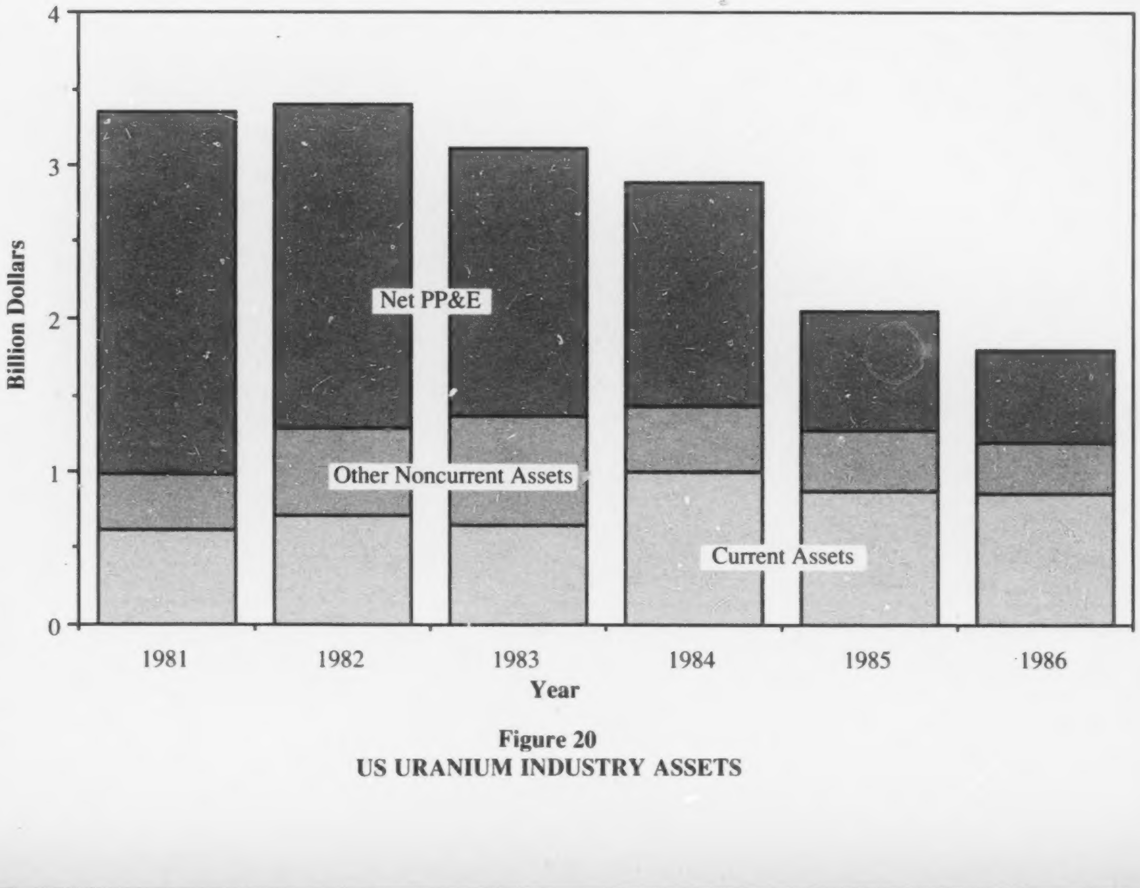


Figure 20
US URANIUM INDUSTRY ASSETS

As can be seen in Figure 20, this writedown process abated somewhat during 1986, but nonetheless continued. The net value (after accumulated depreciation, depletion, and amortization) of the industry's PP&E declined by almost $700 million during 1985 (about 47 percent of the value of PP&E at the beginning of that year); net assets as PP&E declined less than $200 million (or by about one-quarter) during 1986. New investment in PP&E during 1986 was about $20 million, and depreciation, depletion and amortization accounted for about $70 million. Thus, about $150 million of the decline in PP&E presumably represented one-time writedowns, writeoffs and losses during other dispositions (sales) of properties.

Import Commitment Dependency

This criterion is not based on an assumed import supply disruption; it measures the annual committed degree of reliance on import supplies, as a percentage of normal requirements. Normal requirements have historically been taken to mean enrichment feed requirements of the US utility industry. This criterion has not been cited in past nonviability determinations as a causative factor, although two factors are worth mentioning here. First, commitments for future imports in each of the past viability studies have not exceeded 37.5 percent for any two-consecutive year period, but EIA has consistently projected that future import levels would evolve to exceed this threshold.

Second, it has been typical in the past that import commitments for delivery in the next year following a viability determination have increased during the year, such that actual imports during the year exceed 37.5 percent of requirements by the end of the year. The year 1986 was no exception to this trend, as shown in Figure 21. At the beginning of 1986, import commitments for 1986 delivery were at a level of 10.3 million pounds U_3O_8, or 32-35 percent of projected enrichment feed deliveries. However, by the end of 1986, actual imports for the year were 13.5 million pounds U_3O_8, or 44 percent of requirements. A good deal of the increase is accounted for by the advance delivery of South African imports.

Although the import commitment dependency for the years 1988-1990 increased from the end of 1985 to the end of 1986, such levels were still well below the 37.5-percent threshold. Presumably, EIA will again project future import levels to exceed the 37.5-percent figure.

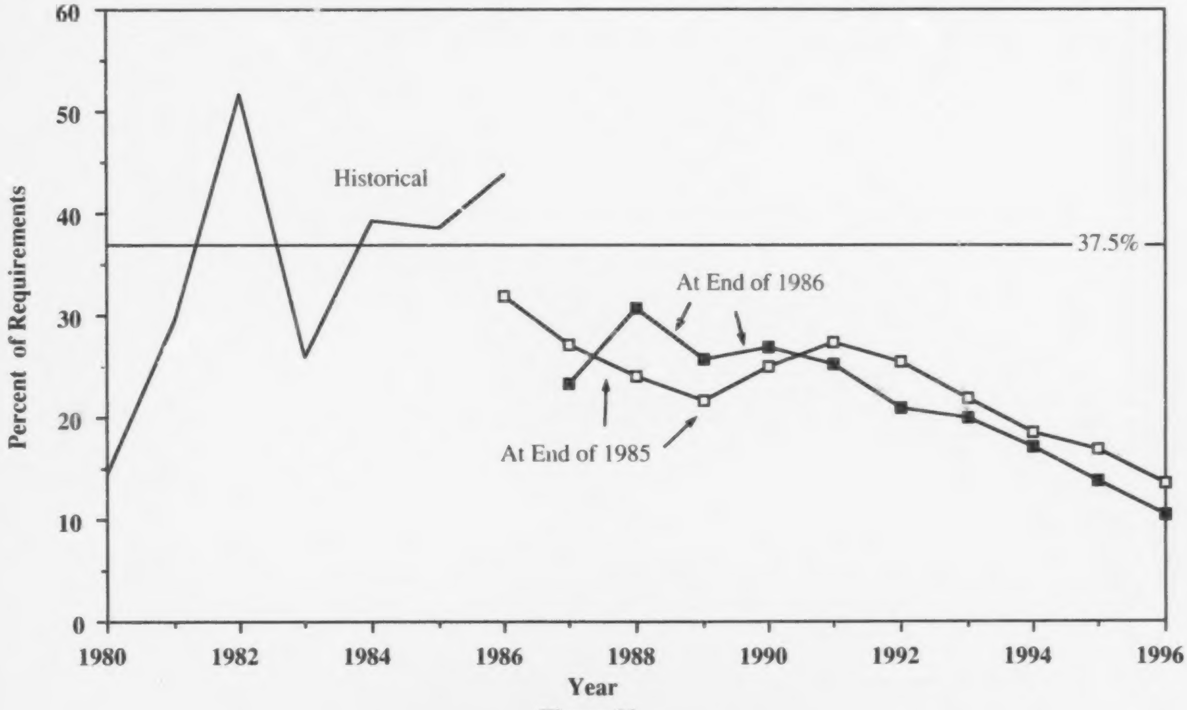


Figure 21
IMPORT COMMITMENT DEPENDENCY

© NUEXCO 1987

Conclusions

During 1986, the US uranium production industry experienced a slowdown in its rate of decline. Production was up slightly primarily due to the milling activity of one high-grade producer. For the third year in a row, the industry as a whole experienced operating and net losses, although not at the same large level as the previous two years. More and more companies have dropped out of serious contention as long-term US producers, but several new companies are beginning operations in the near future. Generally these new producers are involved in more economical unconventional production methods.

US utility inventories continue to decline slowly, and their inventories are increasingly in the more advanced stages of upgrading. New US utility commitments for uranium are heavily weighted toward non-US suppliers, and in fact the overall level of commitments with US producers has declined substantially over the past several years.

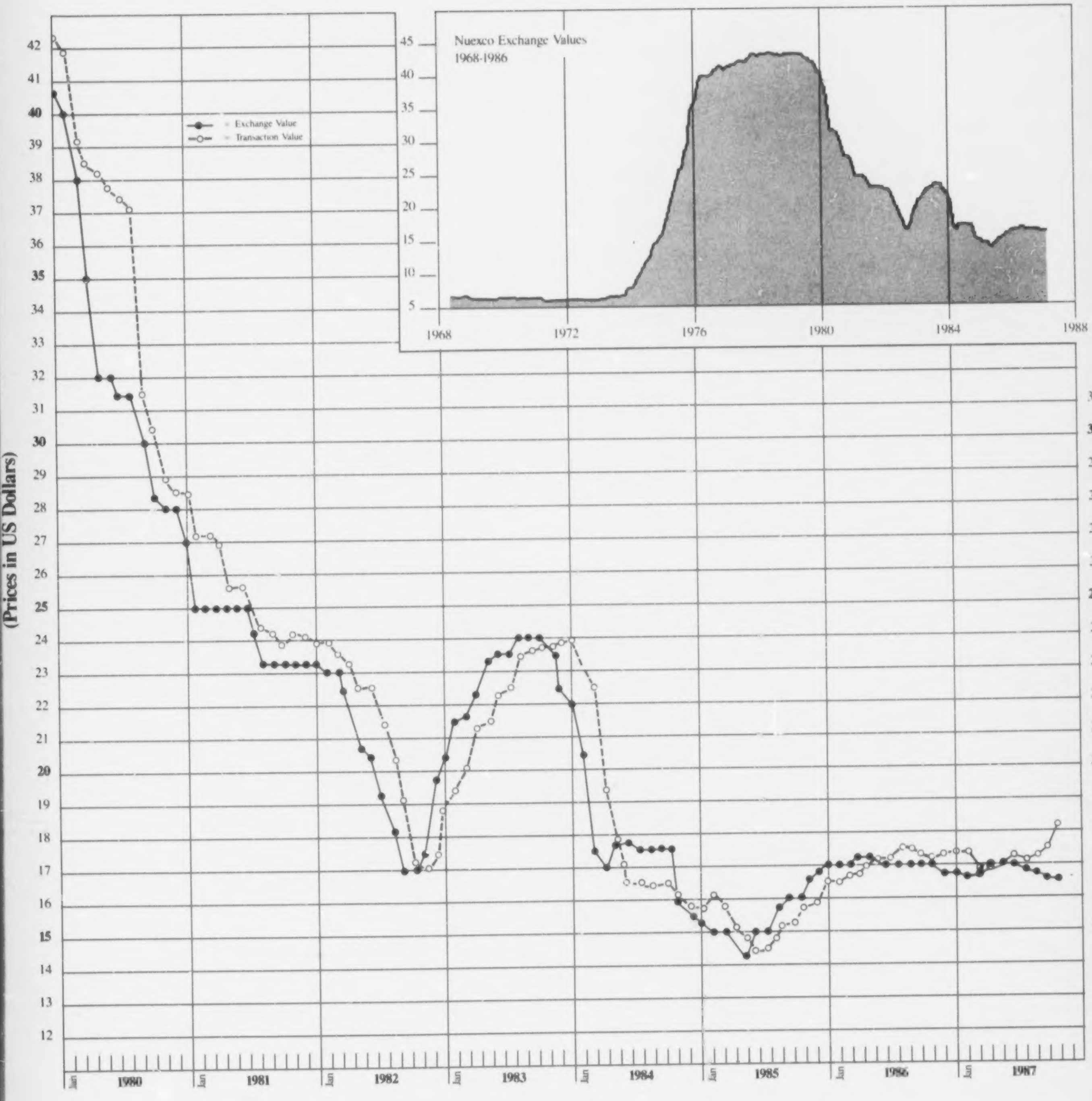
Net contract cancellations and downward adjustments with US producers have been almost counterbalanced by increasing US utility commitments with non-US suppliers, such that the overall annual level of commitments in place for future delivery has remained fairly steady. The level of US utilities' unfilled requirements has also remained steady. Canada maintains its traditional place as the major supplier of US imports, with South Africa in second place. For longer-term import commitments, Australia is supplanting South Africa as the second choice of US utilities (after Canada).

The "viability" of the US uranium industry (for purposes of current Federal law and regulations) seems no more assured than in the previous two years, although the factors involved are changing. The level of future commitments for imports (as a percentage of US requirements) does not exceed 37.5 percent, but actual imports for the past three years have somewhat exceeded that threshold. As more companies have left the US uranium industry, the remaining industry was less unprofitable than in the previous two years, but also is less able to supply US needs in the event of an import supply disruption. If the US industry was not viable in 1984 and 1985, it cannot be declared viable for 1986 unless DOE changes the rules, or the implementation of the existing rules.

(Note: The EIA's "Uranium Industry Annual: 1986" is scheduled for release as Report DOE/EIA-0478(86) on October 23. For more information on its availability, call the National Energy Information Center, at (202)586-8800.)

©NUEXCO 1987

HISTORICAL MARKET DATA



© NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969		6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	**16.65**			

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.30	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.05	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	**18.20**			

©NUEXCO 1987

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	**1.90**			

HISTORICAL UF_6 VALUES

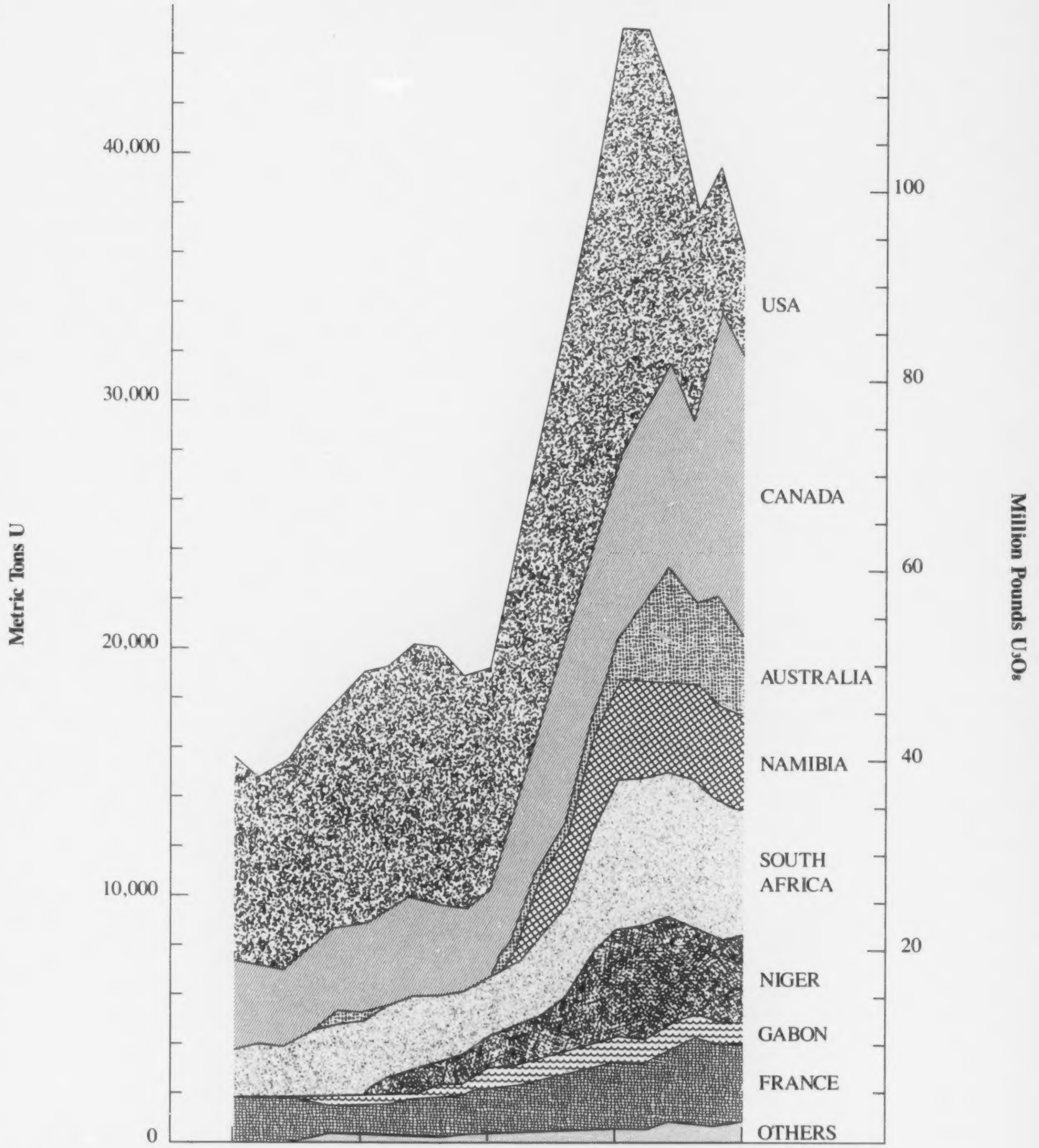
Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	**46.75**			

©NUEXCO 1987

HISTORICAL MARKET DATA

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



---

[1] WOCA = World Outside of Centrally-planned Economic Areas.

[2] 1985 production data are preliminary.

[3] A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

©NUEXCO 1987

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

---

[1] Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity,* DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity,* DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity,* DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983,* DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2] Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry,* GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3] Excludes direct imports by domestic utilities.

[4] Includes imports by domestic utilities and domestic suppliers.

[5] Includes delivery commitments to domestic utilities and agents.

[6] Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

© NUEXCO 1987

HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3]		Spot Contracts[3]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

---

[1] The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar. Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

©NUEXCO 1987

AUSTRALIA

		Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2]	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[3] (1976=100)
1975	Avg.	57.9	150.4	132.6
1976	Avg.	65.7	168.4	160.9
1977	Avg.	73.8	192.0	179.0
1978	Avg.[4,5]	79.7	198.5	190.0
1979	Avg.	86.9	248.8	127.9
1980	Avg.	95.8	321.8	140.8
1981	Avg.	105.0	355.3	154.1
1982	Avg.[6]	116.7	368.6	174.9
1983	Avg.	128.5	401.6	181.8
FY84	Avg.	133.6	95.3	—
FY85	Avg.	142.6	100.0	—
FY86	Avg.	—	105.0	—
Jan	1986	—	109.5	210.0
Feb	1986	—	108.7	210.0
Mar	1986	150.5	99.4	210.5
Apr	1986	—	94.2	210.5
May	1986	—	93.5	210.5
Jun	1986	153.0	95.6	210.5
Jul	1986	—	97.8R	215.3
Aug	1986	—	98.9R	215.3
Sep	1986	157.0	105.4R	215.3
Oct	1986	—	105.9R	215.4
Nov	1986	—	104.9R	215.6
Dec	1986	161.5	105.2R	215.6
Jan	1987	—	106.2R	215.9R
Feb	1987	—	108.9R	216.5
Mar	1987	164.7	108.4R	221.4R
Apr	1987	—	108.3R	221.1
May	1987	—	108.1R	221.0
June	1987	—	108.1R	221.3
July	1987	—	—	221.5

P = Preliminary R = Revised since last month

[1] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81=100.0). Index periods are for normal calandar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. the previous index was 1969 = 100.

[3] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4] Annual Averages are for financial year ending June 30.

[5] Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[6] Monthly data for 1979-82 appear on page 35 of Report 184.

© NUEXCO 1987

GOVERNMENT STATISTICS

CANADA

			Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Industry Products Price Index: All Commodities[1] (1981 = 100)	**Uranium Mines (SIC 057)**	**Metal Mines (SIC 051-059)**	**Mines, Quarries and Oil Wells[3] (SIC 051-099)**	**Primary Non-ferrous Metal Industries[4] (SIC 296)**	**(SIC 298)**	**Chemicals and Chemical Products[5] (SIC 372-379)**
1979	Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980	Avg.	247.2	—	10.58	10.80	—	—	8.50
1981	Avg.	288.7	—	12.02	12.23	—	—	9.53
1982	Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983	Avg.	298.8	—	—	14.30	—	—	11.17
1984	Avg.	310.9	17.88	—	—	—	—	—
Jan	1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb	1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar	1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr	1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May	1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun	1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul	1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug	1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sept	1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct	1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov	1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec	1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan	1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb	1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar	1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr	1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May	1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun	1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul	1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug	1986	119.1	18.39	16.17	15.46	13.31	11.31	12.70
Sep	1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct	1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov	1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec	1986	119.7	19.67	16.79	16.19	13.06	11.57	12.99
Jan	1987	120.0	19.53	16.93	16.01	13.06	12.58	12.89
Feb	1987	119.8	20.33	17.20	16.21	13.01	12.66	13.11
Mar	1986	120.3	20.04	17.14	16.15	13.57	12.58	13.02
Apr	1987	121.1	20.47	17.38	16.26	13.75	11.99	13.27
May	1987	122.0	20.50	17.12	15.96	14.23	11.44	13.19R
June	1987	122.5R	20.23R	16.94R	15.70R	13.65R	12.77R	12.88R
July	1987	123.1	19.87P	16.93P	15.70P	13.71P	12.75P	12.99P

P = Preliminary R = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (3Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)"Æ Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, plus a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data. Wage Earner Data were further revised in January 1987 and now reflect a slightly different base than previously.

[3] Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4] Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5] Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6] Monthly ISPI data for 1977 and 1978 appear on page 4.10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4.11 of Report 138.

[7] Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)".

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.[7]	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.88	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.76	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	740,031	532,577
Feb	1987	—	—	251.0	237.0	757,872	598,986
Mar	1987	88.17	197.1	255.0	239.6	762,697	536,006
Apr	1987	—	—	258.2	242.5	761,850R	533,487R
May	1987	—	—	261.2	243.6	759,421	530,981
Jun	1987	90.74	203.5	263.1	244.9	759,433	573,546
July	1987	—	—	266.2	246.8	—	—
Aug	1987	—	—	270.0	—	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."

[4] The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.

[5] Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.

[6] Bulletin of Statistics, Department of Statistics, Pretoria.

[7] Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.

[8] Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157

[9] Monthly data for 1979-82 appear on page 39 of Report 184.

GOVERNMENT STATISTICS

UNITED STATES

		Producer Price Index[1]		Consumer Price Index[2] (1967 = 100)	GNP Implicit Price Deflator[3,4] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
		Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.[6]	274.8	268.8	246.8	85.7	10.26	10.63	8.30	6.94
1981	Avg.	304.1	293.4	272.4	94.0	11.55	11.98	9.12	7.62
1982	Avg.[7]	312.3	299.3	289.1	100.0	12.31	12.93	9.96	8.21
1983	Avg.	315.7	303.1	298.4	103.9	12.58	13.43	10.59	8.65
1984	Avg.	322.6	310.3	311.1	107.7	13.05	13.43	11.08	9.04
1985	Avg.	323.8	308.7	322.2	111.2	13.38	13.74	11.56	9.46
1986	Avg.	312.2	299.8	328.4	114.1	13.20	13.49	11.98	9.65
Jan	1986	323.8	308.9	328.4	—	13.41	13.68	11.87	9.58
Feb	1986	318.9	304.4	327.5	—	13.46	13.80	11.83	9.57
Mar	1986	314.0	300.3	326.0	112.9	13.41	13.91	11.80	9.60
Apr	1986	311.6	298.2	325.3	—	13.47	13.89	11.84	9.60
May	1986	311.6	299.2	326.3	—	13.40	13.79	11.90	9.63
Jun	1986	311.8	299.0	327.9	113.7	13.50	13.50	11.95	9.59
Jul	1986	308.5	297.4	328.0	—	13.33	13.30	12.05	9.67
Aug	1986	307.9	297.2	328.6	—	12.96	13.13		9.64
Sep	1986	308.7	297.5	330.2	114.7	13.04	13.28	12.03	9.70
Oct	1986	309.6	298.4	330.5	—	12.85	13.16	12.08	9.67
Nov	1986	309.8	298.7	330.8	—	12.75	13.14	12.17	9.73
Dec	1986	309.8	298.1	331.1	114.9	12.70	13.03	12.20	9.82
Jan	1987	313.5	300.9	333.1	—	12.94	12.98	12.18	9.84
Feb	1987	314.9	302.2	334.4	—	12.99	12.83	12.21	9.84
Mar	1987	315.7	302.7	335.9	116.1	13.04	12.79	12.24	9.84
Apr	1987	317.3R	305.0R	337.7	—	13.16	12.90	12.30	9.82
May	1987	318.6	307.3	338.7	—	12.97	12.92	12.31	9.83
Jun	1987	320.2	308.5	340.1	117.2	13.05R	12.93	12.27	9.84
Jul	1987	322.6	310.2	340.8	—	13.07P	13.04P	12.36R	9.89R
Aug	1987	323.8	310.5	342.7	—	—	—	12.35P	9.89P

P = Preliminary R = Revised since last month

---

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4] The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6] Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28 and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139. Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147. Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154. Monthly Data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7] Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-1) 910-8977
Telecopy: (41-1) 910-6672
Telex: 829177 (COMAG CH)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 272-6246
Telecopy: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR